BULLETIN No. 21 1921 ENTOMOLOGICAL SERIES, No. 1

# BULLETIN
of the
# LLOYD LIBRARY
of
## BOTANY, PHARMACY AND MATERIA MEDICA

J. U. & C. G. LLOYD
CINCINNATI, OHIO

ENTOMOLOGICAL SERIES, No. 1

The Biology of

# NORTH AMERICAN CADDIS FLY LARVAE



By

JOHN THOMAS LLOYD

# INTRODUCTION.

Caddis-flies, or Trichoptera, are winged insects with somewhat moth-like appearance, that are mostly nocturnal and usually do not wander far from the watersides. Only rarely do they become conspicuous, and then on account of the great numbers in which they gather about lights, rather than on account of any striking individual habits or appearance. Occasionally they, together with mayflies and insects of a few other orders, congregate about electric lights near large lakes and rivers in such numbers that they become a serious nuisance, and the bodies of their dead collect in piles that must be removed in wagon loads. Usually, however, one who is not making a special hunt for them sees no more than a few individuals that flutter around his light on warm summer nights preceding storms.

Perhaps the larvæ, or caddis-worms—known also as "stick-worms"—are more familiar to the average layman than the winged adults. Almost every child has seen a bundle of crossed sticks jerkily drawn about through the water by an insect with only head and legs projecting. Not all cases, however, are of the cross-stick type, and not all are so familiar to the layman. There are portable cases in almost endless variety of form, and made of almost every material to be found in the water, and there are many larvæ that make no portable cases, but live in silken tubes, awaiting animal prey or plancton to become entrapped in their catching nets. A few caddis-worms make no cases at all, but crawl free among the stones.

Whether the caddis-worms construct portable cases, or silken tubes, or make no cases until almost time for pupation, they all secrete a glue, or silk, through openings in the lower lip, or labium. This silk is produced in large glands within the body cavity. These glands, like the silk-secreting glands of caterpillars, are modifications of the salivary glands, to meet the larvæ's needs for silk. The silk is emitted as a liquid, but has the remarkable character of hardening immediately after expulsion from the larvæ's bodies and of adhering fast to submerged objects, though they be wet and saturated with water. The silk is not usually spun in fine strands, as is that of the Lepidoptera, but is more glue-like, forming a homogeneous sheet over the object cemented.

A few caddis-worms that construct portable cases use no other material than silk in their structure. By far the greatest number of species, however, use stones or sticks cemented around a more or less heavy lining of silk. The cases, regardless of their external form, are circular in cross-section. Some are of uniform diameter, throughout their length, while others taper, cornucopia-like, from a broad mouth to a very narrow caudal end. In building their cases the larvæ add new material to the cephalic end. Some species build rapidly and cut about as much from the caudal ends of their dwellings as they add to the front ends. These species make tubes of uniform diameter throughout their length. Other species add to the front ends of their cases as the larvæ grow in length and breadth, but never remove material from the caudal ends. The result of this form of construction is a case that is of minute size, but large enough to accommodate a newly hatched larva, at its caudal end, and gradually increases in breadth as the larva grows, thus forming a cornucopia-shaped tube. Figures of both types of cases will be found on following pages.

Toward the close of the larval period there is a change in the habits of the caddis-worms. They stop eating entirely and frequently hunt some protected spot, such as crevices in bark or roots, or they burrow into wood or soil. Often the form and material of their cases is greatly altered, and there is almost always a mesh or grating spun across the two ends of the case to protect the helpless pupa against active enemies and the greater peril of silt. After the mesh is spun the larva becomes sluggish and entirely incapable of walking. This stage in the larva's life is called the prepupal period. It usually lasts but two or three weeks, but in the genus Neophylax it extends over the greater part of the summer.

During the active larval period, when the caddis-worms are free to move about and feed voraciously, they lay up a reserve supply of food to carry them through the transformation period and through their adult lives, when they feed little if at all. They then pass through a quiescent or pupal stage. During this period a great change takes place in the structure of the insect. From the worm-like larva, fitted for aquatic life and provided with greatly developed mouth parts and alimentary tract, comes forth a moth-like, winged insect that is air-breathing and has vestigial mouth parts and feeble alimentary tract, and seems to have no other object than to mate and oviposit. So great is the change that no one

could possibly detect the slightest relationship of appearance or structure between the caddis-worm and the adult caddis-fly. Though caddis pupæ are not active, like the corresponding stages in some insects, they are not entirely quiescent. There is always a rhythmic undulation of the abdomen, sending a constant stream of water through their cases, and during the latter part of their lives they are capable of walking.

Trichoptera are the only insects, possibly excepting a very few Diptera (of the genera Simulium and Chironomus), with aquatic pupæ. In several other orders one finds a few species with submerged pupæ, but they all tap the stems of aquatic plants, entrap air in dome-like covers, or in some other way breathe free air. The pupæ or Trichoptera are as much aquatic as are their larvæ.

The eggs of caddis-flies are round or slightly oval in form. The eggs of all, except, perhaps, a few of the Rhyacophilidæ, are laid in masses of gelatin. The masses, when extruded from the bodies of the females, are comparatively small, but rapidly absorb water until they are many times their original size. In form the gelatin mass, and the arrangement of eggs within the mass, is often quite characteristic of the species. In laying the eggs, the females of some species descend beneath the surface of the water and glue the mass fast to some support. Other species dip their abdomens into the water while in flight, apparently washing the extruded mass from the ovipositor, and still other species fasten the eggs to stick or stones above the water, the young falling to the water after hatching.

Very little is known of the eggs and egg-laying habits of most American species.

Trichoptera occur in all parts of the earth where any insects life can exist, but their greatest abundance is reached in the northern temperate zone, and their numbers of species seem to decrease as one nears the equator.

They inhabit all kinds of fresh-water situations, from the most rapid torrents to stagnant swamps and pools. Some species seem to show a decided preference for temporary pools that are filled with water when the autumn rains come, and dry completely with the drought of summer. How these species of Trichoptera, together with some members of several other orders of insects, pass over the period of drought is not altogether certain, but evidence seems to show that they burrow beneath the ground. All known

caddis-worms inhabit fresh water, except a single species from New Zealand that lives in the ocean, and a well-known terrestrial species of Europe that lives in the moss on tree trunks.

In economic importance the Trichoptera rank very high as food for fresh-water fishes. During the summer months the surface-feeding species of fish, such as the trout, obtain a never-failing supply of food from the caddis-flies, as they hover over the surface of the stream and lakes. The larvæ, however, form a much more important article of food for fishes than do the adults. Trout taken from the streams of Ithaca in the early spring are found to have their stomachs gorged with caddis-worms of the genus Neophylax, and to contain no other food. In New Zealand, Hudson examined the stomachs of sixty trout caught at all seasons of the year, and found a total of 5,466 insects. Of these 4,241 were caddis-worms.

Probably no other order of insects is of as great importance in the food of wild trout as Trichoptera, and the day will probably come when caddis-worms are raised by fish culturists as food for their fishes.

In eating caddis-worms, fishes swallow cases and all, their stomach becoming filled with sticks and pebbles, as well as with the bodies of insects.

Aquatic Environment.—To avoid constant repetition on following pages, a brief description is here given of situations in which the greater part of the present work on caddis-worms was done.

Cayuga Lake, a body of water about forty miles long, with an average breadth scarcely exceeding two miles, lies in the valley below the Cornell Campus. It is a deep lake with precipitous sides that rapidly descend to a depth too great for submerged vegetation, except at the two ends, where there are shoals with luxuriant growths of aquatic plants that merge into large cat-tail marshes. The insect fauna of the lake has never been studied.

All of the streams of the region flow into Cayuga Lake. On approaching it they descend rapidly in a series of falls and torrents. In this region of rapid descent their bottoms are of rock and they pass through deep gorges.

Higher up they have more the character of the usual streams throughout the country. They flow in a series of pools with bot-

toms of mud, or silt, or sand, and riffles with bottoms of stones or gravel.

Most of the large streams of the region have their origin in summit marshes, whose drainage often enters two different watersheds. These marshes have bottoms of deep black muck, and are covered with dense growth of vegetation. Alders form almost impenetrable tangles and sedges and grasses, and sometimes bog moss, sphagnum, grow in thick mats under foot, helping to impede the off-flow of water. Through these soft muck bogs the streams meander, their waters always shaded by overhanging alder thickets, supporting hardly any living vegetation. These upland bogs harbor many forms of animal life that are characteristic of such situations, and of the more northern Canadian fauna.

The largest upland swamps are the McLean Bogs and Michigan Hollow, whose southern drainage flows into the Susquehanna River, and whose northern drainage forms Buttermilk Creek, flowing into Cayuga Lake.

More work for the present paper was done in the McLean Bogs than in all other situations together. These bogs are situated along, and near, Beaver Creek, an affluent of Fall Creek, about fifteen miles from Ithaca. They offer not only typical bog conditions, with areas of sphagnum, areas of sedge, and areas of alder swamps, but also several cold swamp streams, an open pond, and numerous large springs.

Since the early days of Cornell, when the hills surrounding the bogs were covered with an impressive growth of huge hemlock trees, till the present time, they have been a favorite collecting ground for students in all fields of biology.

There are also several small lakes in the region. Of these we are concerned with but a few. Beebe Lake, a dilation of Fall Creek, which serves as a reservoir for Cornell University, is convenient to the Campus, but is not very prolific of insect life. Michigan Pond, at the northern end of Michigan Swamp, has soft mud bottom and a profuse growth of aquatic plants. It is a rich collecting ground for aquatic insects. Spencer Lake, in the Susquehanna drainage south of Michigan Swamp, is a beautiful little lake which offers a great variety of aquatic situations. It is rich in caddis-worms, especially the Leptoceridæ.

With these various kinds of aquatic situations within con-

venient working distance, it would be hard to find a spot more favorably situated for work on different types of fresh-water life.

METHODS OF COLLECTING AND REARING.—The methods employed in collecting and rearing the larvæ were quite simple. After the specimens were found, some were put at once into alcohol for future study, and some into formaldehyde for future examination of the stomach contents. Others were caged until the time they emerged, when the species could be determined.

The cages employed were simple cylinders of galvanized screening, over the bottom and top of which a cloth was tied. These cages were placed in natural water as nearly like the situations from which the larvæ were taken as was possible to find convenient to Ithaca. The cages were provided with food material and were partly submerged, care being taken to leave enough space protruding to give the emerged adults ample room above the water.

In carrying living larvæ from place to place it was found that they quickly died if taken from well aerated water and placed in collecting jars. This difficulty was overcome by wrapping them in wet cloths. Experience has shown that aquatic insects will live for long periods of time in cloths that are kept moist, but they must not be left submerged.

In studying the material in the laboratory, balsam mounts were made of the frons, legs, and mouth parts. When possible, the frons and mouth parts were reclaimed from the larval exuvia. This practice eliminates difficult dissections and gives beautiful mounts that are much cleaner than can possibly be obtained by dissection.

For examining the entire larvæ a binocular microscope with various combinations of oculars and objectives was employed.

Many thanks are due to Professor J. G. Needham, Professor O. A. Johannsen, and other members of the staff of the Department of Entomology, Cornell University, for help and encouragement during the preparation of this work.

DISTINCTIVE CHARACTERS OF TRICHOPTEROUS LARVÆ.—Aquatic larvæ[1] having three pairs of jointed thoracic legs and a single pair of abdominal prolegs situated on the last abdominal segment, and terminating in a chitinous hook. All of the abdominal segments are soft, except that some members of the family

[1] Enoicyla, of the European fauna, is terrestrial.

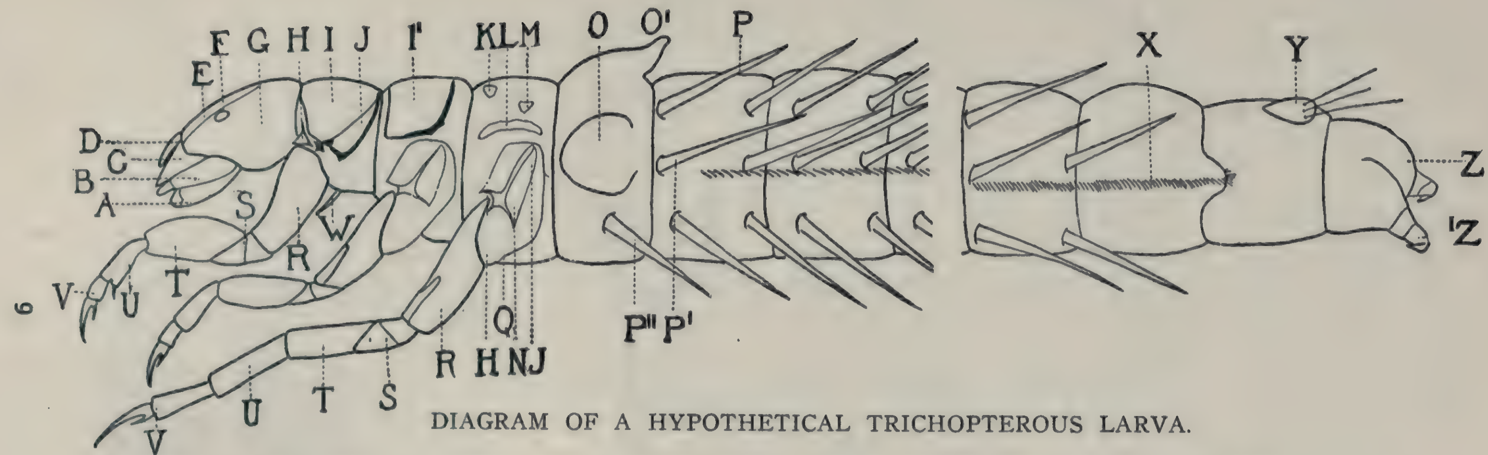



DIAGRAM OF A HYPOTHETICAL TRICHOPTEROUS LARVA.

A—Labium; B—Maxilla; C—Mandible; D—Labrum; E—Frons; F—Eye; G—Gena; H—Episternum; I—Pronotum; I′—Mesonotum; J—Epimeron; K—Cephalic chitinous plate; L—Lateral chitinous plate; M—Caudal chitinous plate; N—Pleural suture; O—Lateral spacing hump; O′—Dorsal spacing hump; P—Sub-dorsal gill; P′—Lateral gill; P″—Sub-ventral gill; Q—Pre-axal swelling; R—Coxa; S—Trochanter; T—Femur; U—Tibia; V—Tarsus; W—Prosternal horn; X—Lateral fringe; Y—Chitinous plate; Z—Proleg; Z′—Drag hook.

Hydroptilidæ have small, dorsal, chitinous plates on certain segments, and a few species in other families have small ventral plates.

Description of the Larvæ. *The Head.*—The head is heavily chitinized. On the dorsal surface there is a somewhat shield-shaped sclerite behind the labrum, which evidently represents the clypeus and the frons, fused into one piece. As the frons represents the larger part of the sclerite, and because the term "frons" is well established in the nomenclature of other orders of insects applying to the clypeo-frons ("clypeus" is used by most writers on Trichoptera), the term *frons* is used to designate the sclerite in the present paper. The shape of the frons varies in different Trichopterous larvæ, and it usually has a quite distinct pattern of color and muscle-attachment marks, as well as different distribution of setæ, for which reasons it is of great use in classification. It is also easily recoverable from the larval exuvia of pupal cases, and often forms the most reliable clue to the determination of pupæ.

Extending back from the frons to the hind margin of the head is the epicranial suture.

On the ventral surface of the head, behind the mouth parts, there is a sclerite, the gula, which varies greatly in size and form. Sometimes it extends to the hind margin of the head, completely separating the epicrania. At other times it is represented by a small, triangular piece, behind which the epicrania are contiguous. At such times the gular suture separates the epicrania behind the gula.

The epicrania form the greater part of the head, extending from the mouth parts to the caudal margin, and from the frons and epicranial suture above to the gula and gular suture beneath.

The antennæ are usually so small that they are easily overlooked; occasionally they are almost as long as the mandibles. They are located behind the outer angle of the mandibles.

The eyes are located on the outer edge of the dorsal margin of the head, sometimes on prominences. They are usually jet black in color and are almost always surrounded by a light-colored area.

The mouth parts are well developed and are formed for biting. The mandibles are very heavily chitinized and offer characters which would be of great taxonomic value, were it not almost im-

possible to get two mandibles into the same position for comparison. When seen from slightly different angles, the form of the mandibles and the comparative size of the teeth, or even the number of teeth, appear very different. Often the mandibles are asymmetrical, differing in their armature of teeth, hairs, and brushes. The labrum is separated from the fused frons and clypeus by a membranous hinge by means of which the labrum folds back within the capsule of the head, often becoming invisible from above without skilled manipulation. The labrum is usually chitinous, but in some families is membranous. It is provided with a few large setæ, often with dense brushes of hairs, and peculiar, cycle-shaped, marginal setæ, which offer good taxonomic characters. The labium and lower mouth parts differ in different families, but only slight study has been given them and they are used but little in classification.

*The thorax* consists of three distinct segments. The dorsal surface of the first thoracic segment, or pro-thorax, is termed the pronotum, and is always covered by a heavily chitinized plate, which extends over the sides of the segment. On the ventral surface of the prothorax there is often a somewhat curved, finger-like process, of doubtful function, which is found in no other order of insects. It is termed the "prosternal horn" or the "horn." The dorsal surface of the two succeeding segments, the meso- and the meta-thorax, are termed the meso- and the meta-nota. The meso- and meta-notum may each bear from one to four chitinous plates, or they may be entirely membranous. On the sides of the three thoracic segments, forming supports for the legs, are chitinous plates which probably represent the episternum and the epimeron. They offer most excellent taxonomic characters, but as yet are but slightly studied and their use has been almost entirely neglected. All of the plates of the thorax are armed with characteristic spines and setæ.

A pair of jointed legs is borne by each thoracic segment. These often arise from bulbous swellings of the integument of the body which closely resemble the coxæ of certain insects and have sometimes been confused with the basal joints of the legs. Commencing at the basal end of the leg, its segments are as follows: (1) The Coxa, a large, entirely chitinized segment. (2) The Trochanter, usually a short, somewhat triangular segment, that is divided by a suture into two pieces of almost equal length. (In the Lepto-

ceridæ, as discussed under that family, there are variations of the trochanter.) (3) The Femur, usually broad and flattened. (4) The Tibia. (5) The Tarsus, which is a single segment bearing a large claw, usually armed with a tooth.

Gills rarely occur on the thorax.

*The Abdomen.*—The abdomen consists apparently of ten segments, or apparently of nine segments. All of the segments, except the last, are entirely membranous, except a few Hydroptilidæ which bear small chitinous plates on certain segments, and a few other forms that have some small ventral plates. The first segment in the case-building forms often bears three "spacing-humps," or tubercles. These tubercles are mound-like elevations of the integument that serve to keep a space between the insect and its case for the free circulation of the respiratory currents of water. They are peculiar to the order Trichoptera. One tubercle is located on the middorsal surface of the segment. It often terminates in a movable, nipple-like process. The other two tubercles, the lateral humps, are situated on the sides of the segment and always end obtusely. On the ventral surface of the segment the cuticula is sometimes raised into a lip-like fold, or it may be entirely flat. It is provided with numerous setæ, which are arranged in definite order and often provide convenient means of classification. Some of the segments between the first and the last, of the case-building caddisworms, usually bear a "lateral fringe," or "lateral line." This is a continuous line of delicate hairs, often situated on a fold of the cuticula, which undulate in a wave-like manner from front to rear, and keep a continuous flow of fresh water passing through the case.

Gills, when present, most commonly occur on the abdomen, where they may be situated near the front or hind margin, or near the middle of the segment. They are always filamentous, but they may arise in tufts or singly, they may be branched or unbranched. Regardless of their location in respect to the cephalic and caudal margins of the segments, they are always arranged in rather definite lines known as: (1) The Lateral Series, which is located near the mid-lateral surface of the body. (2) The Sub-dorsal Series, which is located above the lateral series, just below the dorsal surface of the body. (3) The Sub-ventral Series, which is located below the lateral series, just above the ventral surface of the body.

Besides the external gills many trichopterous larvæ possess anal gills, which are located within the anus and are capable of protrusion. In preserved specimens they are usually completely concealed within the cavity of the body, for which reason they offer unsatisfactory taxonomic characters. Even the external gills are not altogether reliable for taxonomic purposes, except in their general grouping; for tufts of gills often contain different numbers of filaments in different individuals of a species, or even on opposite sides of the same individual. Also, especially on the more caudal gill-bearing segments, the gills on some specimens are very feeble, or drop out entirely, while on other specimens they are well represented. However, the same type of gills is always found in the same species, and the gills that are present always arise from the same parts of the segments.

The terminal abdominal segment bears a pair of more or less fleshy prolegs, each of which terminates in a movable chitinous hook. In some of the case-making larvæ the bases of the prolegs are fused, forming an apparent tenth segment, while in other species they are separate, apparently arising from the ninth abdominal segment. Ulmer considers ten segments usually present, but the weight of evidence points to but nine segments, the apparent tenth being but the fused bases of the prolegs.

Description of the Pupæ.—In external appearance Trichopterous pupæ have many of the characters of the adults. Their legs, antennæ, and wing-pads are free from the body, and their general form is much the same as that of the perfect insect.

The head is formed much like that of the adult. In those forms that have antennæ shorter than the body, the antennæ are straight and are laid close along the sides of the pupæ. In forms with antennæ much longer than the length of the body they project backward along the sides of the insect until nearly reaching the end of the abdomen, when they turn abruptly and entwine round and round its caudal segments. The labrum is very different from that of either larva or adult. It is armed with several very long spines which probably serve to keep the mesh of the pupal case free from silt. These spines have characteristic form and grouping in different species. The mandibles are long and heavily chitinized, usually possessing several sharp teeth. It

FAMILY CHARACTERS OF TRICHOPTEROUS LARVÆ.
Prolegs not fused in median line to form an apparent tenth segment.

| Family | Breadth of Abdomen | Dorsal Surface of 9th Abdominal Segment | Tracheal Gills | Labrum | Length of Frons |
|---|---|---|---|---|---|
| Hydroptilidæ | Much wider than thorax | With chitinous shield | Absent | Entirely chitinized | Normal |
| Rhyacophilidæ | Not much wider than thorax | With chitinous shield | Absent | Entirely chitinized | Normal |
| Hydropsychidæ | Not much wider than thorax | Without chitinous shield | Present. Branched | Entirely chitinized | Normal |
| Philoptomalidæ | Not much wider than thorax | Without chitinous shield | Absent | Entirely membranous. White. | Normal |
| Polycentropidæ | Not much wider than thorax | Without chitinous shield | Absent | Entirely chitinized | Long. The epicrania barely meeting behind its caudal margin |
| Psychomyidæ | Not much wider than thorax | Without chitinous shield | Absent | Entirely chitinized | Normal |

is thought that they are used in cutting through the case at the time of emerging. The maxillary palpi are well developed and have the same number of segments as those of the adults.

The thoracic segments are formed much like those of the adult. The second and third segments have external wing-pads, and all three segments possess jointed legs. The legs are much like those of the mature insect, but often possess long swimming hairs to enable the pupa to reach the surface of the water and a suitable place for transformation.

The abdomen is formed much like that of the imago, but is usually longer and more flexible. Gills and lateral fringe are common among the pupæ. Usually they are found in the same species that possess them as larvæ, but this rule does not always hold true. The dorsal surface of segment one usually bears a chitinous structure that may be paired or single. Its general form, together with its ridges and teeth, offers good family and specific characters. Other segments of the abdomen bear paired chitinous plates near their anterior margins, with armature of stout teeth or hooks directed forward. Besides these, segment five bears a pair of plates on its posterior margin, with teeth directed forward. Rarely similar plates are found on the caudal margins of one or two other seg-

Family Characters of Trichopterous Larvæ.
Prolegs fused in median line to form an apparent tenth segment.

| Family | Tracheal Gills. | Dorsal Surface of Labrum | Breadth of Labrum | Mesonotum | Metanotum | Femur of Hind Leg |
|---|---|---|---|---|---|---|
| Calamoceratidæ | Filamentous | With row of 20 or more heavy bristles | Broader than long | Chitinized | Soft | Not divided |
| Odontoceridæ | In bunches | Normal | Much longer than broad | Chitinized | 2 narrow plates crossing median line and 2 small lateral plates | Not divided |
| Saricostomatidæ | Absent, single or bunched | Normal | Broader than long | Chitinized | Soft | Not divided |
| Mollanidæ | In bunches or branched | Normal | Broader than long | Chitinized | Soft | Not divided |
| Leptoceridæ | Absent, single or bunched | Normal | Broader than long | Chitinized | Soft | Divided or apparently so |
| Phryganidæ | Unbranched, lateral series with black hairs | Normal | Broader than long | Soft or with one pair of minute plates | Soft | Not divided |
| Limnophilidæ | Single, bunched or branched. Never with black hairs | Normal | Broader than long | Chitinized | With 3 pairs of plates | Not divided |

ments. This armature, except that of segment one, is subject to so much individual variation that it is of little systematic importance.

The caudal abdominal segment bears long, slender processes armed with long spines. These are probably used, like the long spines on the labrum, to keep the mesh of the pupal case free from entangled silt.

Toward the end of the pupal instar it is possible to see many of the adult characters through the pupal skin. Thus the armature of the legs and the character of the genetalia can be easily compared to those of the adult.

# The North American Caddis-Fly Larvæ

## FAMILY PHRYGANEIDÆ.

Of the three of four genera of Phryganeidæ occurring in North America, only two genera, Neuronia and Phryganea, have been recorded in the eastern part of the United States. Of these the genus *Phryganea* has four species and *Neuronia* has eight species in this region; three of each genus are known in the larval and pupal stages. The eggs of only one North American species, *Phryganea interrupta,* are known.

The larvæ of the family are usually among the first aquatic insects attracting the attention of students of entomology. Large, brightly colored, caterpillar-like insects that jerkily drag their cases about in the clear waters, they can not pass unobserved.

Though the larvæ do move about and feed in the daytime, they are typically creatures of the night. If one watches them in an aquarium he will find that a large part of the day is spent in rest, with the front end of the case fastened to some support by a film of silk. When night comes, the cases are loosened and the larvæ crawl actively about, greedily feeding upon whatever vegetation their abode affords.

The immature stages of the Phryganeidæ are better known than those of any other family of American Trichoptera. Our better knowledge of them is perhaps due to their conspicuousness and the ease with which they can be fed and reared in captivity. Omnivorous plant feeders, and dwellers in ponds or slowly flowing streams; furnished with a great area of gill surface which is constantly bathed with changing water pumped by the unceasing rythmic waves of the body, they thrive in laboratory aquaria.

The greatest danger that besets the captive larvæ, when several are confined together, comes at the time of pupation. After the earliest have attached their cases and have become inactive, they fall easy prey to the ravenous appetites of those still active. In nature, however, due to the burrowing habits of the larvæ before their activity ceases, it is probable that they are seldom disturbed by others of their kind.

Distinctive Characters of the Larvæ.—The larvæ are brightly colored with dark-brown or black on the yellow background of the heavily chitinized parts of the head and prothorax. The abdomen and soft parts of the meso- and meta-thorax, in life, are green or reddish green.

The body in cross-section is almost circular. The head turns down at an angle of about 45 degrees; the last abdominal segment also turns down. The prothorax is heavily chitinized above the coxæ and bears no tufts or setæ; the meso- and meta-thorax are entirely soft except a minute pair of bristle tufts. The gills are finger-like and arise singly, the postsegmental gills of the median series bear fine black hairs—continuations of the lateral fringe.

Description of the Larvæ.—*The Head.*—The head is long and somewhat flattened. Each antenna consists of a single short cylindrical segment set in a pyramidal base. The tips of the ventral margins of the epicrania are almost contiguous behind the somewhat triangular gula. The labrum is broader than long, rounded into two lobes which are separated in front by a narrow area having its edge indented into about eight scallops; the margins of the labrum are bordered with a rather sparse fringe of hair; four setæ on the margin are pale in color and are curved inward so that they lie almost parallel to the margin, the other setæ are normal; on the under side there are three pairs of spearhead-shaped setæ with their points directed inward, these show through prepared mounts and often appear as if on the upper surface. The mandibles are stout, with more teeth on the left mandible than on the right; brushes on the mandibles are wanting. The lower mouth parts are well developed; the maxillary palpæ and maxillary lobes are about equal in length.

*The Thorax.*—The prothorax is heavily chitinized above the base of the forelegs. The venter is soft, except the somewhat triangular sternellum. The "horn" immediately in front of the sternellum is long, slender, and curved forward. The pleural suture is sunken, giving a grooved appearance to the hind margin of the segment. The trochantine is acute and spur-like, extending beyond the margin of the foreleg. Clusters of setæ are lacking.

The meso- and meto-thorax are soft, except the heavily chitinized episterna and epimera. On the dorsal surface of each of

these segments there is a pair of slight prominences, each of which bears clusters of about five large and several smaller setæ.

The legs are long, and terminate in slender, curved tarsal claws; those of the first pair are shortest and stoutest, while those of the third pair are longest and most slender. The inner margin of each femur and trochanter is fringed with a dense single line of pale hairs.

*The Abdomen.*—The segments are deeply constricted at the sutures, giving the abdomen a decidedly ringed appearance. The spacing-humps on the first segment are large; the dorsal hump is directed backward and bears a pointed nipple-like process at its tip; it is apparently incapable of motion; the lateral humps lack the nipple-like process and can be moved at the will of the larva. The lateral fringe is black, sparse in front, and growing increasingly denser toward the rear; the gills are long and finger-like, and are arranged singly; on each segment the hind gills of the medium line are stoutest and lie close to the body; their firm articulation makes it apparently impossible for them to sway in currents, as do the other gills; these postsegmental gills bear fine black hairs—continuations of the lateral fringe. On the dorsal surface of the ninth segment there is a raised chitinous plate which bears four prominent, and several small, setæ on its hind margin. Above each proleg there is a line of several setæ.

Description of the Cases.—The cases are cylindrical tubes of thin, rectangular bits of leaves arranged spirally (Phryganea, fig. 41) or in a series of rings (Neuronia, fig. 18). The lining is a thin sheet of tough but pliable silk.

### Key to the Genera of Phryganeidæ Larvæ.

A. Frons with median stripe, or with no markings. Case a spirally wound cylinder.—*Phryganea.*

A.A. Frons with dark markings, which are not in the form of a median stripe. Case a cylinder composed of rings of leaf sections placed end to end.—*Neuronia.*

### Key to the Genera of Phryganeidæ Pupæ.

A. Mandibles lance-like, or sickle-like, several times as long as broad.—*Phryganea.*

A.A. Mandibles rhomboidal, only slightly longer than broad.—*Neuronia.*

## Genus Neuronia.

Habitat.—Neuronia larvæ may be found in our fauna almost wherever there are slowly moving streams of spring water. Rarely they are found along the edge of the large warm streams where cool seepage enters. They prefer slowly moving water, but seem to have little preference whether it be a shallow seepage, barely deep enough to submerge their cases, or the deep pools of upland streams. In still water only *N. concatanata* has been taken. This occurs in Michigan Pond.

Larval Habits.—The larvæ of Neuronia are bottom-dwellers whose habit is to crawl over the floor of their cold spring stream, or to rest among its trash and litter. They can, and do at times, climb about on the vegetation, but typically they are of the bottom.

When the season for pupation draws near, the larvæ of Neuronia burrow into wood, or wedge themselves beneath bark, or in crevices, as do the larvæ of Phryganea, or if the stream bottom be of clay they may burrow into the soil itself. Pupal life beneath a loose, silty soil would be fatal.

Larvæ pupating under natural conditions, as described above, do not shorten their cases. If kept in an aquarium, where opportunities for burrowing are not at hand, the larvæ will cut off the case to a length slightly longer than its body and attach it to some supporting plant for pupation.

Food of the Larvæ.—Leaves of all kinds and in all states of preservation enter into the food of Neuronia larvæ. Dead leaves, however, are more frequently consumed than the leaves of living plants, but the choice seems due to the chance of environment rather than to a preference of appetite. On the bottoms of the streams where Neuronia occur, green plants are scarce. When they do occur they are eaten without discrimination.

Distinctive Characters of the Larvæ.—The only characters yet discovered for separating the larvæ of this genus from those of Phryganea are the color pattern of the frons. All known larvæ of North American Neuronia have lateral markings on the frons, which may connect in U-like forms across the caudal region of the sclerite. A median stripe is never present.

The larvæ are slightly more robust than those of Phryganea.

The spacing-humps are larger, and the abdominal segments less constricted, giving the larvæ a less scalloped appearance.

DISTINCTIVE CHARACTERS OF THE PUPÆ.—The pupæ of Neuronia may easily be distinguished from those of Phryganea by their short rhomboidal mandibles, almost as broad as long.

DESCRIPTION OF THE CASE.—The cases of the known species of North American Neuronia are easily distinguished from any other known cases. They have the form of very slightly bowed cylinders, varying in length, but always much longer than the body of the larva, and tapering very little, if at all. The cylinders are composed of a series of rings placed end to end. Each ring is made of broad quadrilateral sections of leaf. The rings are neatly fitted without overlapping, in the cases of old larvæ. Young larvæ sometimes leave the caudal ends of the leaf fragments protruding in long strips.

The cases of the larvæ of American Neuronia differ remarkably from those of the European members of the genus. In Europe the cases are described as spirally built, like those of Phryganea. When a careful study of the adults and larvæ from America and Europe is made, it may be found that there are generic differences of structure correlated with this difference of habit in case-making.

### KEY TO THE SPECIES OF NEURONIA LARVÆ.

A. Mesonotum without chitinous plates. Frons with a dark mark on each side, not connected to form a U-like pattern. —*N. postica.*

A.A. Mesonotum with two minute chitinous plates near its cephalic margin. Frons with the dark marginal marks connected behind to form an irregular U-like pattern.

B. Robust larvæ measuring 30 mm. when mature. Markings dark.—*N. pardalis.*

B.B. Less robust larvæ, not exceeding 20 mm. in length. Markings less prominent than in N. pardalis.—*N. stygipes.*

## NEURONIA PARDALIS.

HABITAT.—The larvæ have been taken only in Argus Brook and in the old mill-race, at McLean, but adults on the wing in Michigan Hollow and in Bear Swamp indicate that the species also breeds in those localities.

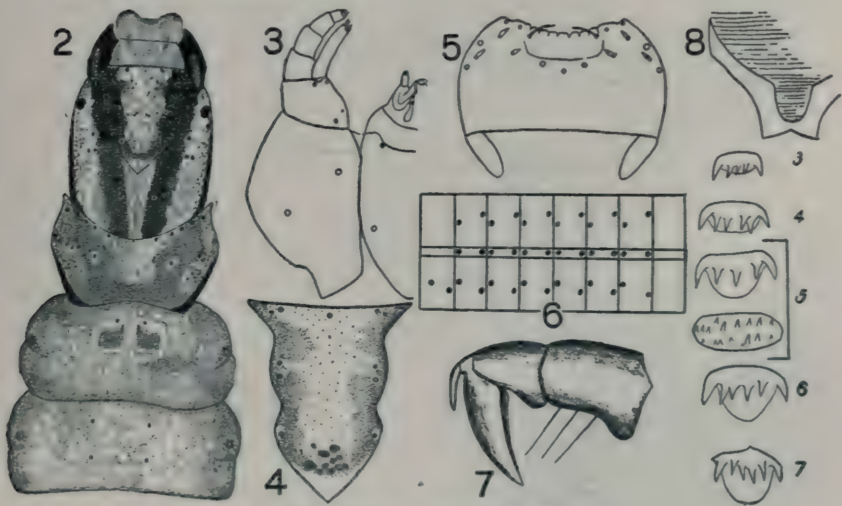
LARVAL HABITS.—The habits of *N. pardalis* do not seem to differ from those of *N. postica.*

PREPUPAL HABITS.—No pupæ were taken under normal conditions, but probably, if known, their habits would be found like those of other members of the genus.

In captivity, where no opportunity for burrowing was offered, the cases were tightly attached to vegetation before pupation took place.

FOOD OF THE LARVÆ.—No stomach examinations were made, but the food eaten in captivity does not differ from that taken by *N. postica.* Probably in nature the diet of the two species is the same.

DESCRIPTION OF THE LARVA.—Length, 32 mm.; breadth at second abdominal segment, 5 mm.




NEURONIA PARDALIS.

2. Larva. Head and thorax.
3. Larva. Lower mouthparts.
4. Larva. Frons.
5. Larva. Labrum.
6. Larva. Distribution of giills.
7. Larva. Drag-hook.
8. Pupa. Chitinous plates of left side of abdomen.

*The Head.*—Light straw color with black markings arranged on the dorsum as in figure 2; on the side there is a black mark commencing at the prothorax and ending a short distance behind

the eye, the upper margin of this mark is bordered by numerous small round spots and near its cephalic end a narrow line extends downward, connecting it with the black mark of the venter; each side of the venter is marked by a broad black patch which extends from the base of the mandibles to the caudal margin of the head; the mandibles are jet black, except for a brown mark on the outer margin.

*The Thorax.*—The markings of the dorsum are shown in figure 2; on each side of the third segment a sharply defined black mark extends obliquely upward to the caudal margin of the segment; on the venter there is a black, somewhat triangular mark reaching from the caudal margin of the segment to the base of the "horn;" the "horn" is light in color and apparently weakly chitinized. The second thoracic segment has a group of about eight setæ in a light-colored area on each side of the dorsum; the sides, except the legs, are without markings; the venter is without markings; the third segment has a group of about eight setæ on each side of the dorsum, its sides and venter are without markings.

The legs are straw-color marked with black.

*The Abdomen.*—In life it is dark-green with a distinct reddish tinge, especially on the dorsal side; the gills are pale reddish; the arrangement of gills is diagrammatically shown in figure 6.

Description of the Pupa.—Description made from a cast skin. The mouth parts are weakly chitinized; the labrum is rectangular with rounded corners, about 1.5 times as long as wide; the mandibles are about half the length of the labrum and are almost as broad as long, a projection on the outer side bears two prominent setæ on its tip; the lateral fringe commences on the cephalic margin of the fifth abdominal segment and loops under the caudal margin of the eighth segment; a pair of sucker-like discs occurs on the dorsal surface of the caudal margin of the last abdominal segment; each disc has a single seta on its outer margin and a group of three large setæ beneath its cephalic margin; the first abdominal segment has a striate appearance above, as in figure 8. The arrangement of teeth on the dorsal plates is serially illustrated in figure 8.

## Neuronia Postica.

Habitat.—This species is found in cool, slowly moving streams, fed by springs or in drainage from upland bogs. Like

other members of the genus, it prefers the deep shade of the forest, and is often found in streams which are littered with leaves but void of living vegetation. It occurs sometimes where the seepage from bogs furnishes scarcely enough water to submerge its case, and at other times it is found on the bottom of the deepest pools of upland streams. In the Cayuga Basin it is the most widespread member of the family.

LARVAL HABITS.—The larvæ spend their days crawling about or resting among the leaves of the stream. At night they are more active and feed almost unceasingly. They are bottom-dwellers that seldom climb into the vegetation.

Unlike members of other genera of Trichoptera, this species, and probably other species of the genus, frequently abandon their cases. Often during spring the larvæ may be found without their cases, and in the winter they have been observed through the thin ice crawling naked among the leaves on the stream's bottom. When they enter submerged trash their cases prove cumbersome, and are abandoned. How frequently this occurs one comes to realize when, while seeking the larvæ, he encounters case after case without its occupant, and seldom a case inhabited. The form of the case, also, indicates that they are not long retained. Their uniform diameter proves that they are constructed more rapidly than the diameter of the larvæ increases.

That larvæ under natural conditions often find and enter their deserted cases is improbable, but in captivity the cases are usually reclaimed. Often, when several specimens are kept in the same aquarium, a caseless larva will enter the rear end of an inhabited case, crowding the owner out before him. The owner, when so treated, almost invariably crawls down the outside of the case and himself enters at the rear. Thus ownership many times alternates until finally one becomes discouraged and abandons the case to the other.

A few weeks before time for pupation the larvæ seek places of safety in which to spend their inactive period of metamorphosis. Their hiding place may be the thick mat of roots along the stream's edge, or it may be the soil of the stream's bottom, but more often it is a water-soaked root or log.

When pupation takes place among roots, the larva crawls deep into the thickly entangled root-mat of the bordering alders, where

it makes its case fast with a cement of silk. Here it is protected against the ravages of prowling enemies and against the greater danger of suspended silt.

Those larvæ which transform in the earth of the stream's bottom, enter the soil where it is firm and hard; submergence in silt would mean their destruction. When entering the soil the larva stands on its head, with its case perpendicular to the bottom, and slowly enters, dragging its case with it. I do not know by what method digging is accomplished.

FOOD OF THE LARVÆ.—The larvæ eat vegetable matter of almost every kind. In the laboratory they show little preference between dead or living plants, terrestrial or aquatic. Under natural conditions, as shown by examinations of stomachs of larvæ taken in the streams, both dead leaves and fresh aquatic plants, when the latter are to be had, are consumed.

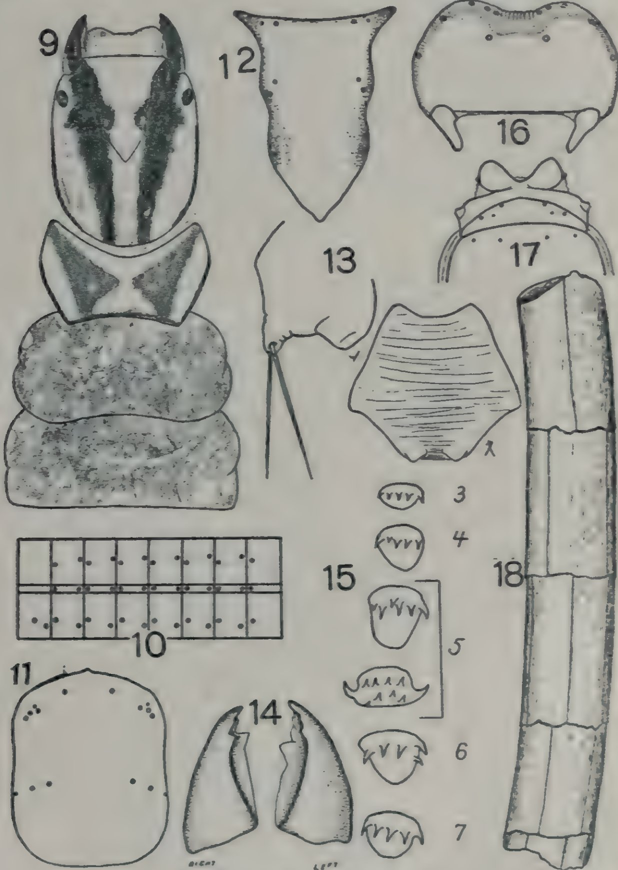
PERIOD OF EMERGING.—The imagoes first appear early in May and continue to emerge until late June. In emerging, the pupæ swim to the surface of the water, transform, and take flight without climbing onto any support. Their cast pupal skins are often common objects along the margins of upland streams.

DESCRIPTION OF THE LARVA.—Length, 30—35 mm.; breadth, 4.5—5 mm.

*The Head.*—Straw-yellow marked with dark-brown as follows: A mark starting at the base of each mandible extends diagonally back along the outer edge of the frons to the hind margin of the head, almost touching the epicranial suture; a mark begins behind and slightly below each eye and extends to the hind margin of the head, almost paralleling the upper mark; a white area surrounds each eye. The under side of the head is slightly cloudy, but does not have the well-developed smoky stripe of *N. stygipes*. The mandibles are dark-brown, except for a triangular spot on the outer surface, which is lighter. The labrum and the sclerites of the lower mouth parts are straw-colored, narrowly bordered with brown.

*The Thorax.*—The prothorax is straw-yellow, marked with dark-brown; the pattern of the dorsal surface is shown in figure 9. The epimeron is dark-brown, narrowly bordered with black; the ventral side of the prothorax is white, with a triangular black chitinous piece behind the "horn."

The meso- and meta-thorax on their upper surface are without dark marks, but have a pattern of minute white spots arranged in narrow lines (figure 9); the arrangement and extent of this pat-




NEURONIA POSTICA.

| | | |
|---|---|---|
| 9. Larva. | Head and thorax. | |
| 10. Larva. | Distribution of gills. | |
| 11. Pupa. | Labrum. | |
| 12. Larva. | Frons. | |
| 13. Pupa. | Mandible. | |
| 14. Larva. | Mandibles, under side. | |
| 15. Pupa. | Chitinous plates of left side of abdomen. | |
| 16. Larva. | Labrum. | |
| 17. Pupa. | Caudal end of abdomen. Ventral side. | |
| 18. Case of larva. | | |

ern is subject to some variation; the ventral surface is without marks. The epimeron is brown, with a narrow black mark in the form of an inverted T.

*Abdomen.*—The distribution of gills is indicated in figure 10.

DESCRIPTION OF THE PUPA.—Length, 20—25 mm. The mouth parts are weakly chitinized. The labrum is rectangular, with rounded corners, about one and a half times as long as wide (figure 11). The mandibles (figure 13) are a little longer than wide; a broad lobe on the inner corner of the front margin is without setæ; a smaller, somewhat finger-like lobe on the outer corner bears a pair of long setæ on its tip.

The lateral fringe commences on the cephalic margin of the fifth abdominal segment and loops under the caudal margin of the eighth segment. The last abdominal segment is deeply notched, as shown in figure 17; the sides of the notch are flat and disc-like on their dorsal surface. The shield on the dorsal surface of the first abdominal segment is finely striated with transverse marks, as shown in figure 15. The chitinous plates of the succeeding segments are shown in the same figure.

## NEURONIA STYGIPES.

HABITAT.—The only locality record for the immature stages of this species is a short area near the headwaters of Argus Brook, in the McLean bog. In this region the larvæ are not uncommon.

LARVAL HABITS.—The larvæ wander actively about through the trash of the stream's bottom until the middle or latter part of April, when they burrow into the soil or into dead wood for pupation.

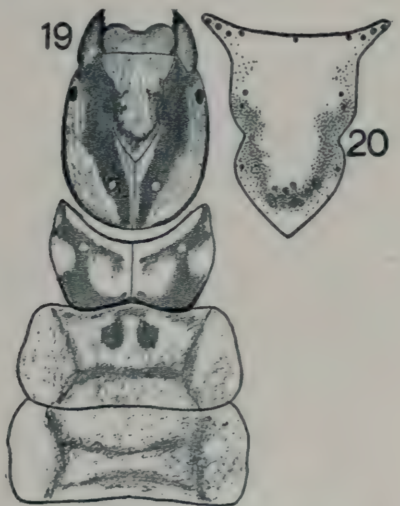
PERIOD OF EMERGING.—The habits of the species when emerging are like those of *N. postica*. In captivity emergence took place during the last two weeks of May. During the same period adults were common along the stream where the larvæ were found.

The adults were seen only close to the stream from which they emerged. Here they flew about with slow, jerky flight close to the low vegetation beneath the dense alder thicket, or skimmed the surface of the small stream. When resting they sought the shelter of low weeds or grass.

Due to their habit of flying during the light of day, and of remaining close to the borders of the stream, the adults of this species are more readily seen than are those of other species of the genus, which are nocturnal and wide wanderers.

Food of Larvæ.—The stomachs examined contained nothing but fragments of disintegrated leaves—the only soft vegetable matter in the stream where the larvæ were found. It is probable that this species, like *N. postica,* has little preference for the kind or condition of the leaves it eats, and that the variety of its diet is in about the proportion of the variety of the soft plant materials in the water it inhabits.

Description of the Larva.—Length, 20 mm.; breadth, 3 mm. No structural or color characters have been found to separate the larva of this species from *N. pardalis*.




NEURONIA STYGIPES.

19. Larva. Head and thorax. 20. Larva. Frons.

*Head.*—Straw-yellow marked with dark-brown, as shown in figure 19. A dark-brown mark starting at the base of each mandible extends diagonally back parallel to the outer margin of the frons, to the hind margin of the head, where the two almost touch the epicranial suture; a dark-brown mark begins slightly behind and a little below each eye, and extends back to the hind margin of the head; on the under side from the mouth parts to the hind margin the head is clouded with smoky brown; between this clouding and the postocular mark the straw color of the head is unshaded; a narrow white area surrounds each eye. The frons (figure 20) has the straw-yellow ground color of the rest of the

head; a dark-brown mark begins slightly behind each mandible and follows the inner margin of the frons until nearly reaching its caudal angle, where it makes a U-like curve, leaving a small area of the caudal part of the frons unmarked.

*The Thorax.*—The sternum of the prothorax is straw-yellow, the dorsum marked with a somewhat variable pattern of smoky brown, as shown in figure 19; the episternum is smoky brown in color, narrowly bordered with deep black along its hind and lower margins; on the under side the prothorax is straw-yellow, except the chitinous triangle, which is dark-brown. The mesothorax has a variable pattern on its dorsal surface; it also has two dark-colored chitinous plates near the mid-dorsal line. The metathorax has a variable pattern on its dorsal surface.

*The Abdomen.*—The soft abdominal parts of the material at hand have been injured by drying.

## Genus Phryganea.

Habitat.—In this region Phryganea larvæ have been found only in the ponds and pools of the Renwick marshes and in Michigan Pond. Occurrence of adults at Sheldrake Point, where there are similar ponds, and on the campus, near Beebe Lake, makes it seem probable that the genus is not uncommon where suitable ponds of thick submerged vegetation exists.

Larval Habits.—Phryganea larvæ dwell, for the most part, among submerged plants above the water's bottom. They are among the few Trichoptera larvæ that can readily be taken with a water net. In moving from place to place, however, when the branches of the supporting plants are not intermixed, they must become bottom-crawlers. Unlike Triænodes, a genus of Leptoceridæ, with which their cases and habits have some things in common, they are not provided with swimming hairs, and are incapable of progress by swimming. Phryganea larvæ differ from the larvæ of Neuronia in their persistent occupation of their cases. They never abandon their cases to wander naked through the water. Correlated with this habit one finds their cases more tapered than those of Neuronia, indicating that they have been retained through a period of growth.

In preparing to pupate, the larvæ of Phryganea leave their abode among the living plants and travel to some submerged log

or chunk of wood. Here they turn at right angles to the surface and slowly burrow into the wood until the last bit of the case is concealed. The operation sometimes requires several days of labor. When sufficient depth is reached the larva spins a silken mesh across each end of the case.

Sometimes, when the bark of the log is loose, the larvæ take advantage of the natural condition and pupate between the bark and the wood, or they may wedge themselves into some natural crevice. Boring into the wood, however, seems the most common method of concealment.

Food of the Larvæ.—Stomachs of larvæ taken under natural conditions contained green plant tissue of various species. Apparently the larvæ feed upon green tissue because of their habit of living among living plants, where the accumulation of dead material does not occur, rather than through any choice of appetite. In aquaria, among a mixture of living and dead plants, they displayed no preference for either sort. Each was eaten with equal greed.

Description of the Larvæ.—The larvæ of the known species of North American Phryganea can most easily be distinguished from the larvæ of Neuronia by the color patterns of the frons. In Phryganea the color is confined to a medium stripe, except in *P. vestita,* in which a pattern is entirely absent.

The larvæ are slightly more slender than those of Neuronia. The spacing-humps are not quite so strongly developed, and the abdominal segments are more rounded, giving them a more pronounced scalloped appearance.

Description of the Pupæ.—The pupæ of Phryganea differ from those of Neuronia in having long, slender, lance-like mandibles—many times as long as broad.

Description of the Case.—The cases of Phryganea have the form of straight tubes (figure 41) composed of narrow strips of leaf arranged in spiral form around the circumference of the case. The spiral of the same species is sometimes wound from right to left, sometimes from left to right. The cases of mature larvæ are tapered very slightly, if at all, but those of immature larvæ taper much more than do those of immature Neuronia larvæ. The young of both genera often fail to cut the leaf fragments used in

the construction of their cases into the rectangular form characteristic of older larvæ. Such cases, (figure 40) with their long, protruding ends of leaves, appear superficially very different from those of mature larvæ. Careful examination beneath the protruding ends, however, will reveal the characteristic ringed or spiraled arrangement of the bases of the untrimmed leaves.

The cases of Phryganea larvæ might, from description, be confused with those of Triænodes. In Triænodes the case is much smaller and more flexible. Its spiral is more plainly apparent than the spiral of Phryganea, and the leaf fragments are much narrower —in most examples almost thread-like.

### Key to the Species of Phryganea.

A. Frons without dark markings.—*P. vestita.*

A.A. Frons with a median mark.

B. Median mark extending the entire length of the frons. Dorsal surface of the prothorax margined in front and behind with dark. No conspicuous dark markings on meso- and meta-thorax.—*P. interrupta.*

B.B. Median dark mark not reaching the hind margin of the frons. Prothorax not margined in front and behind with dark, but with two converging dark marks. Meso- and meta-thorax with two nearly parallel longitudinal dark marks.—*P. cinerea.*

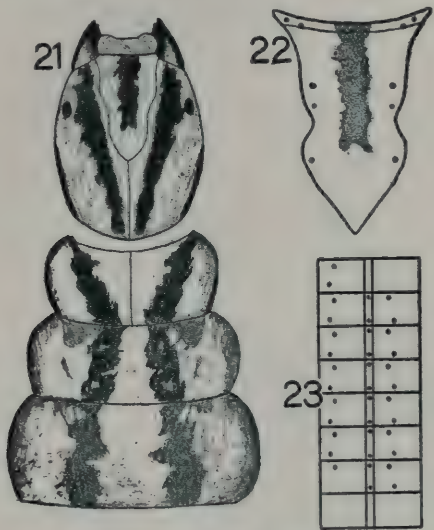
## Phryganea Cinerea.

Habits.—This species is not known to me in life. The specimens from which the description is made were taken by Dr. C. Betten at Old Forge, New York.

Although none of the larvæ were reared, it seems probable that they are *P. cinerea,* for all known species of the genus, which might occur in this state, have been reared, except *P. cinerea* and *P. improba. Improba* is a very rare species, represented in collections by only a few specimens. Cinerea is more common and was taken at Old Forge by Dr. Betten during the season in which he collected the larvæ.

When collected, August 8th, one larva had spun the sieves across the openings of its case, indicating that its growth was complete and that it would have emerged about one month later.

Description of the Larva.—The length of the larvæ is 17 mm., and the breadth at the third thoracic segment is 2.5 mm.




PHRYGANEA CINEREA.

21. Larva. Head and thorax. 23. Larva. Distribution of gills.
22. Larva. Frons.

*Head.*—Figure 21 shows the color pattern of the head. Its ground color is straw-yellow, marked as follows: A median mark begins on the front margin of the frons and extends back about three fourths of its length; a mark begins above the base of each mandible and extends diagonally back between the eye and the frons to the hind margin of the head; a line begins behind and below each eye and extends diagonally upward and backward to the hind margin of the head, where it meets the dorsal marks of the thorax; the under side of the head is without marking, except for a narrow margin of brown at the base of the mouth parts. The eyes are black.

*The Thorax.*—The prothorax is straw-yellow with dark marks which form continuations of the lateral marks of the head and converge toward the mid-dorsal line as they approach the hind margin of the segment; the epimera are dark-brown.

The meso- and meta-thorax are marked above with two almost parallel dark stripes which form continuations of the dark marks

on the prothorax and extend to the hind margin of the metathorax. Each epimeron is marked with dark-brown.

The legs are straw-yellow with a dark-brown mark on the front of each coxa.

*The Abdomen.*—The abdomen is marked on its upper surface with two parallel dark stripes, which form continuations of the thoracic markings. These marks are less conspicuous than those of the thorax and become fainter as they reach the caudal segments.

The gill arrangement is shown in figure 23. The caudal gill is lacking from the ventral series and segment 8 is without gills.

## Phryganea Interrupta.

Larval Habitat.—In the region of Ithaca larvæ of *P. interrupta* have been taken, together with those of *P. vestita* in Michigan Pond and in the pools about the University Biological Field Station. Vorhies, who reared this species at Madison, Wisconsin, found it common in several situations of standing water "where Elodea occurs." In our locality the species is found in some situations where no Elodea grows, and it seems to us improbable that the presence of Elodea has any influence on the distribution of the larvæ.

Larval Habits.—The activities of the larvæ, so far as known, are like those of *P. vestita.*

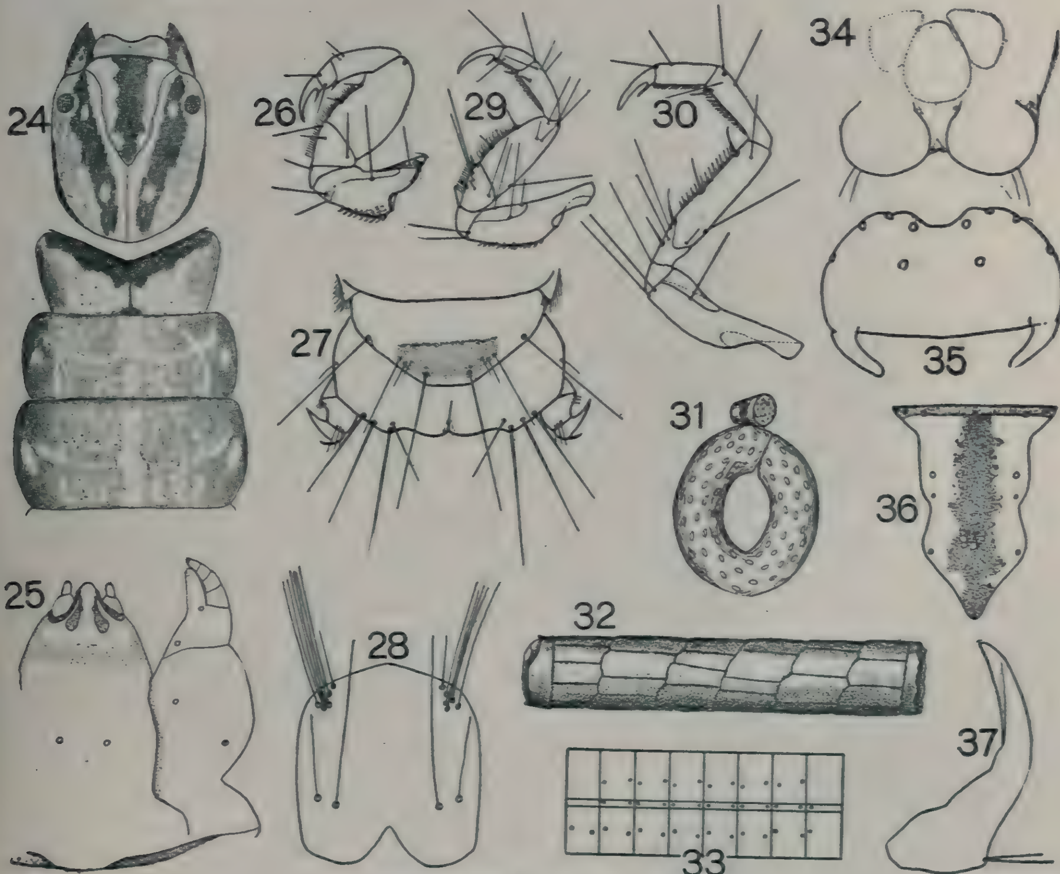
Although pupation takes place and the adults are on the wing together with those of *P. vestita,* the larvæ obtain their growth very much sooner than those of that species. By the first of January the larvæ of *P. interrupta* have obtained full growth, measuring thirty millimeters in length. At the same time the larvæ of *P. vestita,* from the same situation, measure only twelve to twenty millimeters in length.

In preparing to pupate, the habits of this species do not differ from those of *P. vestita.*

Period of Emerging.—Adults emerged from the last of May until the latter part of June.

Food of the Larvæ.—The stomachs of specimens examined contained about the same proportion of dead and green plant tissue found in the stomachs of *P. vestita.*

Vorhies speaks only of Elodea as food of the larvæ. No Elodea occurs in some of the situations of our region where the species is common. Probably Vorhies would have found his specimens feeding as readily on the leaves of other plants if opportunity had offered.




PHRYGANEA INTERRUPTA.

24. Larva. Head and thorax.
25. Larva. Lower mouthparts.
26. Larva. Front leg.
27. Larva. Caudal end of abdomen, dorsal.
28. Pupa. Labrum.
29. Larva. Middle leg.
30. Larva. Hind leg.
31. Egg mass.
32. Case of pupa.
33. Larva. Distribution of gills.
34. Pupa. Caudal end of abdomen, ventral side.
35. Larva. Labrum.
36. Larva. Frons.
37. Pupa. Mandible, lateral view.

Description of the Larva.—Length, 30—35 mm.; breadth, 5 mm. The head and thorax are considerably broader and flatter than those of *P. vestita.*

*Head.*—The ground color is light straw-yellow. A dark-brown mark begins at the front margin of the head behind each mandible and extends obliquely back, paralleling the side of the frons, to the hind margin of the head, where it almost touches the mid-dorsal line. A dark-brown mark begins a short distance behind and below each eye and extends back to the hind margin of the head. The eyes are narrowly bordered with white. The frons is traversed from the front to the hind margins by a dark-brown median mark with irregular margins (figure 36).

The mandibles are dark-brown and black, except a somewhat triangular mark on the outer margin, which is paler; other parts of the head are straw color.

*The Thorax.*—Straw-yellow, marked on its upper surface with brown, as shown in figure 24. The pronotum is margined in front by a narrow line of very dark brown; behind this line there is a brown mark, on its hind margin there are similar but narrower markings of brown which, in the normal position of the larvæ, are covered by the metathorax.

The meso- and meta-thorax are light-green in life, with fine colorless markings, which are subject to considerable variation in pattern.

The supra-coxal plates are dark-brown, margined with black.

The legs are straw-yellow with narrow black marks on the outer edges of the bases of the coxæ, and shadings of light-brown on the margins. The outer surfaces of the coxæ of the first and second pairs of legs are thickly set with minute thorns, plainly visible only in prepared mounts, but much larger than those of *P. vestita,* in which species the thorns are visible only with the compound microscope.

Description of the Pupæ.—Only cast pupal skins are in our collection. Vorhies states: "Length, 25—28 mm.; width, 6 mm. Antennæ extending to the sixth segment. Body in life, green; a fuscous band extending along the dorsal wall of the abdomen on either side."

Our cast skins show the following characters: The mandibles (figure 37) are almost twice as long as the labrum. The lateral

fringe is dense and black. The anal appendages (figure 34) are short.

Description of the Eggs.—The eggs have been found by Vorhies, who states: "An egg mass taken from vegetation in the water of Lake Wingra on July 21 proved to be of this species. It consisted of a cylindrical mass of clear jelly 6 mm. in diameter, in which the eggs were imbedded; the ends of this mass were bent around and united so as to form a perfect circle, with a diameter of 3 cm."

Figure 31 represents an egg mass of an undetermined species of this genus which was collected in a pond at North Fairhaven, New York.

## Phryganea Vestita.

Habitat.—The larvæ have thus far been found in only two localities—Michigan Pond and the pools about the Cornell Biological Field Station. In these localities they are not uncommon.

Larval Habits.—From late summer until early spring the larvæ spend an active life on submerged vegetation. Rarely they are found crawling on the bottom.

In early spring, when time for pupation draws near, the larvæ seek the protection of some soggy submerged stick or log. Into this wood they slowly bore, dragging their cases with them, until they are completely beneath the surface—sometimes several inches beneath the surface. The work of boring is accomplished very slowly. The only larva observed during the process was found in the Field Station pools. When discovered, this larva had bored about one-half inch into a piece of soaked wood. The front end of the case was fastened firmly within the hole, and the hind end protruded from the surface at right angles. From day to day it drew farther into the wood until, at the end of a week, only the tip of the case remained protruding. During the operation the chunk was left in the pool where found. No dust or fragments of wood accumulated about the larva, and it was not known whether the waste was torn loose and extruded between the larva and its case, or whether it passed through the larva's alimentary tract. The larva's case fit so snugly in the hole that nothing could have passed outside it.

All pupæ found were beneath the surface of wood, usually in

holes which they had evidently made for themselves, though sometimes they were in cracks or between the bark and the wood. The front ends of the cases were fastened tightly, sometimes so tightly that pressure broke them before pulling them loose from their support.

FOOD OF THE LARVÆ.—Stomachs examined contained almost entirely green leaves of aquatic plants. Only a few contained dead vegetation, but the choice undoubtedly was due to the environment of feeding, rather than to any choice of the larvæ.

PERIOD OF EMERGING.—Specimens emerged June 10 to 20. Emergence was not observed, but the similarity of Phryganea pupæ to those of Neuronia in habitat, habits, and structure indicates that emergence is accomplished as in that genus.

DESCRIPTION OF THE LARVA.—Length, 25—30 mm.; breadth, 3.5 mm. In life the color of the chitinous parts is pale straw-yellow with dark-brown markings.

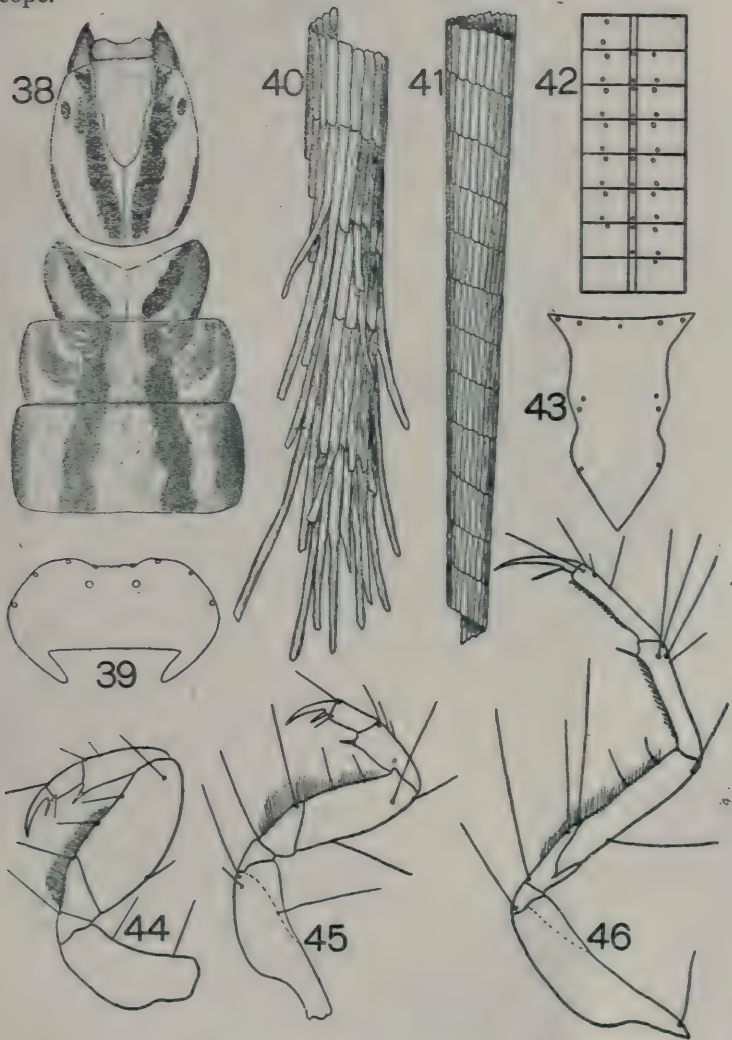
*Head.*—The color pattern of the upper surface of the head is shown in figure 38; its ground color is straw-yellow, lighter around the eyes; a dark-brown mark extends back from the base of each mandible, touching the margin of the frons, and passing on to the hind margin of the head; on the sides of the head an oblique dark mark begins behind each eye and extends back to the hind margin of the segment, paralleling the dorsal dark mark. The eyes are jet black. The frons (figure 43) is straw-yellow without markings, but is slightly darker than the ground color of the head. The mandibles are stout; the left mandible has three teeth above and three below, while the right mandible has but two teeth above and two below.

*The Thorax.*—The prothorax is straw-yellow with two oblique dark-brown marks, forming continuations of the lateral marks of the head, on its upper surface. The posterior sclerites of the propleura are dark-brown, margined with black on their caudal and lower margins.

The meso- and meta-thorax are brownish green in life, marked somewhat as shown in figure 38; the markings of these segments vary somewhat in different specimens.

The legs are straw color with dark-brown markings on each coxa and a mark of lighter brown along the back of the front femur. The legs are more slender than those of *P. interrupta,* and

the thorns on the first and second coxæ are much more minute—invisible except in prepared mounts under the compound microscope.




PHRYGANEA VESTITA.

38. Larva. Head and thorax.
39. Larva. Labrum.
40. Case of young larva.
41. Case of old larva.
42. Larva. Distribution of gills.
43. Larva. Frons.
44. Larva. Front leg.
45. Larva. Middle leg.
46. Larva. Hind leg.

Description of the Case.—The case is tubular, tapering gradually from front to rear, and is not curved (figure 41). It is made of narrow, somewhat quadrangular, bits of leaves arranged in spiral form, wound from right to left. Different cases vary considerably in size, but usually they are about 5 cm. long, 5 mm. wide at the front, and 3 mm. wide at the hind end. The spiral usually has from 10 to 12 turns.

The case of the pupa is about 36 mm. long and has little or no taper. It is sealed at both ends with a sieve of silk.

## FAMILY LIMNOPHILIDÆ.

Habitat.—Limnophilid larvæ are fitted for life in almost every aquatic situation. In pond and slow-moving streams, especially those that dry completely during the drought of summer, their numbers far outnumber all other Trichoptera together. As the water becomes more swift the number of species becomes less, until in the swiftest water, in which loose stones come to rest, one finds only species of the genus Neophylax, but these often in great numbers. They are absent from the brinks of falls and from the parts of streams where the waters rush over bare bedrock.

Apparently in direct relation to the kind of water inhabited the development of gills has taken place. In those species that inhabit standing water the gills are large and numerous—often many-branched. In species of faster moving water the gill surface is noticeably less, and in Neophylax—the Limnophilid of the rapids—the gills are few and are reduced until hardly more than thread-like rudiments.

To this family belongs the European Enoicyla, which has the only terrestrial larvæ known to occur in the order Trichoptera.

Larval Habits.—Little can be said that will cover the habits of all of the Limnophilid larvæ. The habits of each species are discussed separately on the following pages.

In preparing for pupation the larvæ retire to some secluded spot where there is little danger of molestation during the quiescent pupal period. One species at least, *Limnophilus indivisus,* buries itself among the submerged roots of sedges; more often the larvæ hide in the crevices of sticks or stones. So far as we know, only the larvæ of Neophylax remain in the open. These larvæ attach

their tough stone cases to the edges of rocks in swift water, without search for protecting crevices.

In this family, with the exception of the genus Neophylax, we have noted no attempt at gregarious grouping, except when accident brings the larvæ together. In Neophylax there is an unmistakable gregarious instinct developed when the prepupal period approaches. At this time larvæ gather in compact masses on certain parts of certain stones, while other similar stones in the same part of the stream remain uninhabited.

FOOD OF LARVÆ.—It seems probable that the larvæ are altogether herbivorous when living under natural conditions, but in the confines of aquaria they will often become carnivorous, or even cannibalistic.

The vegetation eaten by most species consists of vascular plants, living or dead, with more consideration for the convenience of the larvæ than for the condition of the food.

A few species, such as *Limnophilus submonilifer,* rasp the soft outer portions from submerged sticks and stems, and thus procure a diet that is often a mixture of higher plant tissue and diatoms—sometimes it is almost altogether diatomaceous ooze.

PERIOD OF EMERGING.—From the time when Platyphylax begins to emerge, while the first warm spring sun still shines on the snow of late winter, until Neophylax and a few others cease their flight in the snow of early winter, there is no period without some species of Limnophilid.

Though on the wing from the snows of spring till the snows of fall, the adults are found in maximum numbers of species during late spring or early summer. In June, for a short time only, the greatest number of species are in flight, but there are other species for every period of the summer, and a few, such as *Limnophilus submonilifer,* continue to emerge during the greater part of the summer. Such species do not have a definite season when all the individuals occur as larvæ, pupæ, or adults, but can be found in all stages during most of the summer.

DESCRIPTION OF LARVÆ.—In form the larvæ are cylindrical. The head fits well into the first thoracic segment and is carried pointing downward at a decided angle to the rest of the body. The

first and second thoracic segments are chitinized dorsally, and the third segment bears three pairs of chitinous plates.

*The Head.*—The head is generally oval, sometimes decidedly tapering toward the mouth parts. The gula is triangular or elongate, and the epicrania are contiguous, or nearly so, behind its base. The labrum is broader than long, variously armed with bristles and hairs. The mandibles are stout, with blunt rounded teeth, and a pair of setæ on the outer surface and a brush on the inner surface.

*The Thorax.*—The dorsal surface of segments 1 and 2 is completely covered by chitinous shields. On the ventral surface of the prothorax there is usually a slender curved "horn" directed forward between the bases of the forelegs. The metathorax is soft, except for three pairs of chitinous plates; of these the lateral pair is somewhat crescentric in form and occurs slightly above the bases of the metathoracic legs; the median pair is small and somewhat oval or triangular, and is located near the cephalic margin of the segment; the second pair is small and of varying form, and is located more laterally and posteriorly than the median pair.

*The Abdomen.*—The abdomen is cylindrical in cross-section and of nearly uniform diameter throughout its length. Its first segment is provided with three more or less perfectly developed "spacing-humps" or callous spots. Gills are always present, but vary greatly in number and arrangement; they occur on the first segment, so far as known, only in an unidentified species of the genus Limnophilus. The lateral fringe is present, but is sometimes very feeble. The last segment bears a chitinous plate on the dorsal surface. The first segments of the prolegs are fused to form an apparent tenth segment.

DESCRIPTION OF THE CASE.—The larvæ of the various genera of the Limnophilidæ make cases of great variety of form, and of almost every obtainable material.

In spite of their great variety of form and material the cases can, with a few exceptions, be readily determined by an observer with a little experience.

To this family belong the log-cabin type of cases; the cylindrical cases with little or no taper, made of rough fragments of bark, or sticks, or leaves, shells, or seeds; the cylindrical cases with heavy ballast sticks at the sides; also cases made of leaf fragments

that are triangular in cross-section; and flat, two-sided cases of leaf fragments.

All members of the family are makers of portable cases, but, so far as known, there are no spiral cases, and none made of a series of rings placed end to end; there are no cases that are four-sided in cross-section, and none that are made entirely of silk.

In the genus Neophylax the larvæ make cases of sand with large ballast stones at the sides, which are very similar to cases made by some of the Sericostomatidæ, but are more slender, smaller, and made of lighter material. A few genera (only Platyphylax as yet described from America) make curved, tapering cases of sand grains that quite closely resemble the cases of certain Leptoceridæ. Though there are fairly constant characters for determining the cases of the family, it is impossible to give characters for separating all of the cases generically or specifically. Often the cases of different individuals of a single species differ more widely from each other than from cases of species of widely different genera.

**Limnophilidæ with gills arising in tufts of two or more. A dark colored longitudinal line on frons.**

| Name | Color Pattern on Frons | Lateral Margins of Dark Mark on Frons | Prothorax |
|---|---|---|---|
| Glyphotaelius hostilis | Black longitudinal mark | Parallel, not widening to include lateral setæ of front row | Light, except dark brown on front and hind margins, and median furrow |
| Limnophilus rhombicus | Brown longitudinal mark, usually forked at anterior end | Not parallel, widening toward front to include lateral setæ of front row | Mottled with brown without distinct light colored band behind median furrow |
| Halesus indistinctus | Black longitudinal mark | Not parallel, widening toward front to include lateral setæ of front row | Solid brown-black along front margin. A broad light band behind transverse furrow |
| Limnophilus indivisus | Black longitudinal mark. Sometimes forked at anterior end. | Not parallel, widening toward front to include lateral setæ of front row | Solid brown-black along front margin. A broad light band behind transverse furrow |

(*Tables continued on page 42.*)

LIMNOPHILIDÆ WITH GILLS ARISING SINGLY.

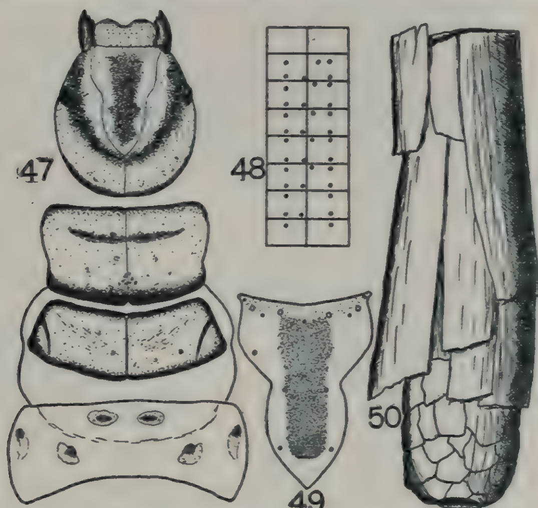
| NAME | BROWN MARKS ON FRONS | PROTHORACIC HORN | EACH SIDE OF MESOTHRACIC SHIELD | SPACING HUMPS | VENTRAL SURFACE OF FIRST ABDOMINAL SEGMENT |
|---|---|---|---|---|---|
| NEOPHYLAX CONCINNUS | Muscle-attachment marks only | Absent | Margins only deep black | All present | With pair of thumb-like projections |
| NEOPHYLAX AUTOMNUS | Muscle-attachment marks only | Absent | Margins only deep black | All present | Without projections |
| ARCTOECIA MEDIALIS | Muscle-attachment marks only | Present | Margins only deep black | Dorsal hump absent, lateral humps present | Without projections |
| ASTENOPHYLAX ARGUS | Mottling besides muscle attachment marks | Present | A deep black isolated spot in each outer caudal angle | All present | Without projections |
| HALESUS GUTTIFER | Mottling besides muscle-attachment marks | Present | Margins only deep black | All present, dorsal hump nipple-like | Without projections |
| PYCNOPSYCHE SCABRIPENNIS | Mottling besides muscle-attachment marks | Present | Margins only deep black | Flattened or slightly rounded, Dorsal hump not nipple-like | Without projections |

Limnophilidæ with gills arising in tufts of two or more. Without dark colored longitudinal mark on frons.

| NAME | COLOR PATTERN OF FRONS | SETÆ ON CAUDAL HALF OF 1ST ABDOMINAL SEGMENT, VENTRAL SIDE |
|---|---|---|
| PLATYPHYLAX DESIGNATUS | Entirely light, except few brown spots | Scattered, not arising in two clusters behind middle of segment |
| CHILOSTIGMA DIFFICILE | Uniformly brown | Scattered, not arising in two clusters behind middle of segment. |
| PLATYCENTROPUS MACULIPENNIS | Entirely black, except caudal margin and few brown spots | Gathered in two groups. |
| LIMNOPHILUS SUBMONILIFER | Light, except caudal margin and sparse brown mottlings. | Scattered, not arising in two clusters behind middle of segment. |

## Glyphotælius Hostilis.

Habitat.—Full-grown larvæ were not uncommon during the fall of 1919 in the cove and pools about the Field Station. During previous summers a few larvæ were taken in the same locality, but




GLYPHOTAELIUS HOSTILIS.

47. Larva. Head and thorax.
48. Larva. Distribution of gills.
49. Larva. Frons.
50. Case of larva.

never in sufficient quantities to work out the life history of the species. In the summer of 1919 the larvæ were found in great numbers in the ditches of the Swamp at North Spencer. Hitherto the species has never been recorded from New York State.

Habits.—The larvæ were found climbing on submerged vegetation and crawling over the bottom, together with *Phrygane vestita* and *P. interrupta.* Nothing is known of the larvæ during the first instars.

Period of Emerging.—A single specimen emerged in the laboratory on April 5.

Description of Larva.—Length. 30—35 mm.; breadth, 5 mm. In life the soft parts are green and the chitinous parts are pale-yellow and dark-brown or black.

*The Head.*—A black band commences at the base of each mandible, and, touching the upper margin of the eye, curved inward

to the point of the frons, where the two meet (figure 47); a black band encircles the hind margin of the head; the frons is marked with a longitudinal stripe (figure 49), and is margined in front with brown; the mandibles are black; otherwise the head is straw-yellow.

*The Thorax.*—The prothorax is completely margined with black, except a narrow space at the base of each coxa; there is a dark-brown mark in the shallow transverse furrow, and an ill-defined brown area in front of the black caudal margin; otherwise the prothorax is pale yellow. The dorsal plate of the mesothorax is pale yellow, more or less mottled with brown, and with a border of dark-brown or black; in some specimens a curved black line crosses each caudal corner of the plate. On the metathorax the chitinous plates are dark-brown, more or less nearly surrounded by a lighter border.

*The Abdomen.*—On the first segment the spacing-humps are well developed; a few setæ arise from a small dark spot on each side of the cephalic margin of the dorsal hump; on the ventral surface there is a mound-like elevation bearing a pair of chitinous spots from which several setæ arise; on the ventral surface of each segment, three to seven, there is an oval chitinous disc, and on the eighth segment there is a pair of smaller discs; the gills are unusually broad and long, from one to three or four filaments arising from a single stem, but the number of filaments, and even the number of gills, is subject to very great variation in this species; figure 48 diagrams the distribution of gills for an average specimen.

Description of the Case.—In length the cases of mature larvæ are from 3.5 mm. to 5 mm. They are made of irregularly-shaped sections of leaves, as shown in figure 50; at the caudal end of the case the ends of the leaves are drawn abruptly in, leaving a round hole considerably smaller than the diameter of the tube.

## Limnophilus Combinatus.

Habitat.—The larvæ are common in the slow-moving streams of Michigan Hollow, McLean marshes, and other upland localities.

Habits.—During their early life the larvæ frequent the grass and sedges which fringe the edges of the streams. As the time for pupation draws near they wander from the edges where marsh

grass abounds, to the middle of the stream where living vegetation is entirely absent. Here they attach the front ends of their cases firmly to some solid support, as a stick or stone. Often many of these pupæ are found congregated on a single small stick, while on the other sticks in the region they are entirely absent.

Food of the Larvæ.—The food consists, apparently, entirely of vegetable matter. Several stomachs from specimens taken at different periods of late spring and early summer were examined. These contained only the tissue of higher plants, but it seems probable that during the cold weather, when diatoms abound, these may compose a considerable portion of the diet of this species.

Period of Emerging.—This species is one of a few Trichoptera known to us which emerge during a long period. On May 22 there were pupæ in the stream, but no empty cases were found. On June 7 the first specimens in captivity emerged, but at that time there were many empty cases in the stream. From June 7 until July 22, when the last captive specimen emerged, their transformations in the cages were of almost daily occurrence. On the latter date, however, there were still many pupæ in the stream, and also a few prepupæ. From this data we may assume that the species is on the wing from early June until the middle of August.

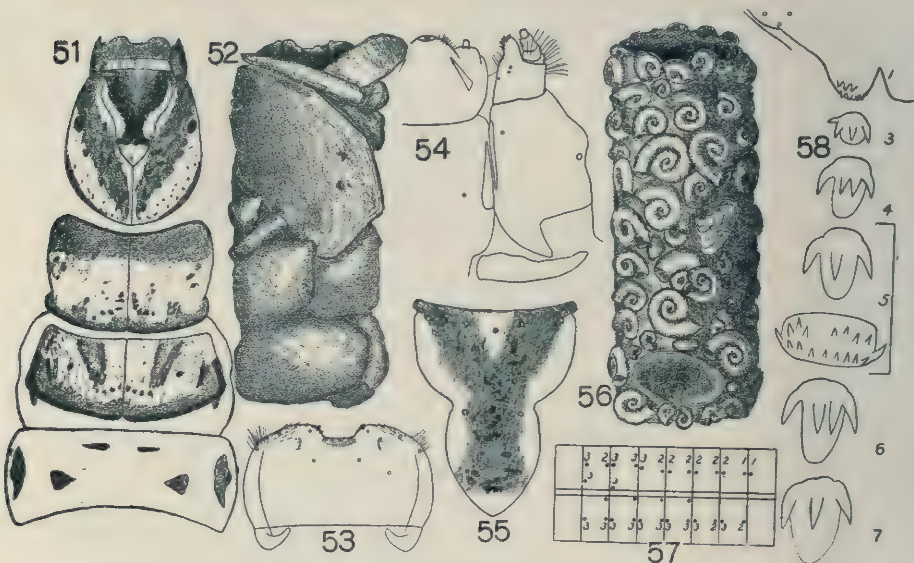
Description of Larva.—Length, when mature, 17—20 mm.; breadth, about 4.5 mm.

*Head*.—The dorsal markings are shown in figure 51; on the sides the head is light-brown mottled with dark-brown or black in the region behind the eye; the venter is light-brown in front, becoming darker toward the hind margin. The labrum is shown in figure 53; the frons in figure 55, and the labium and maxillæ, in part, in figure 54. .

*The Thorax*.—The dorsal markings are shown in figure 51; on the sides, above each coxa, there is a dark chitinous plate bearing a group of setæ near its front margin; the venter is uniform in color. The "horn" on the ventral side of the prothorax is slender and evenly curved forward. The legs are dark-brown, margined and mottled with dark-brown and black.

*The Abdomen*.—The first segment is darker in color than the succeeding segments; it is armed with a few setæ in the region of the humps and on its ventral surface; segments two to seven bear

a few minute setæ; segment eight is bordered along its hind dorsal region by a dark area which bears a row of about six setæ; segment nine curves sharply downward and is darker in color than segments two to eight; it bears a dorsal chitinous plate which is




LIMNOPHILUS COMBINATUS.

51. Larva. Head and thorax.
52. Case.
53. Larva. Labrum.
54. Larva. Lower mouthparts.
55. Larva. Frons.
56. Case.
57. Larva. Distribution of gills.
58. Pupa. Chitinous plates of left side of abdomen.

armed with four large and several smaller setæ; there are also several strong setæ in the region of the drag-hooks; on the under side of each segment, two to seven, there is a narrow hair-like mark, oval in shape; the lateral fringe is short and black. The distribution and number of gills on the left side of the body are indicated diagrammatically in figure 57.

Description of the Pupa.—Length, 20—22 mm.; breadth, about 5 mm. The antennæ extend back to about the hind margin of the seventh segment; on the dorsal surface of the head, between the antennæ, there is a pair of strong setæ, and on the front surface, midway between the dorsal setæ and the labrum, there is a pair of similar setæ; each lobe of the labrum bears a group of stout

setæ which are curved, but not hooked, at their tips. On the second and third pairs of legs the swimming hairs are well developed. The lateral fringe is thick and black; the projections of the last segment are much as in *L. indivisus* (figure 64). The dorsal surface of the first abdominal segment and the chitinous plates (the latter subject to variation in the number of teeth) are shown (left side only) in figure 58.

THE CASE.—Length, 20—25 mm.; the breadth varies greatly according to the material used in construction. The young larvæ, before they leave the grass on the stream's edge, make a case of the cross-stick type common in this genus. When, as the time for pupation draws near, they migrate away from the grassy area, their cases take on an entirely different appearance, being constructed of shells, or small chunks of bark, or seeds, from the bottom. In the meadow area at Michigan Hollow the building material used, after their migration from the shore line, consisted almost entirely of the shells of water snails—*Planorbis* and *Sphærium*, for the most part—and of oval seeds. Figure 56 shows a case from this area. Higher up in the same stream, where the waters are overhung with thickets, the larvæ use chunks of bark in the construction of their cases (figure 52). Different combinations of these materials are frequently found, and sometimes cases are encountered in which the front part is made of shells or chunks, while the hind part retains the cross-stick construction used in its previous environment.

## LIMNOPHILUS INDIVISUS.

HABITAT.—Upland pools or ponds which are rich in decaying vegetation and are subject to desiccation during the middle or latter part of summer.

In waters which it inhabits this species is found in extraordinary numbers, its cases almost covering the bottom of the pond during the late larval period.

HABITS.—During the period when water covers their habitat the larvæ can be found clumsily drawing their bulky cases over the bottom of the pond or climbing over the vegetation. Their activity, apparently, does not cease during the winter months.

Early in May, close examination of a pond where the larvæ had been found in great abundance, covering the bottom with an

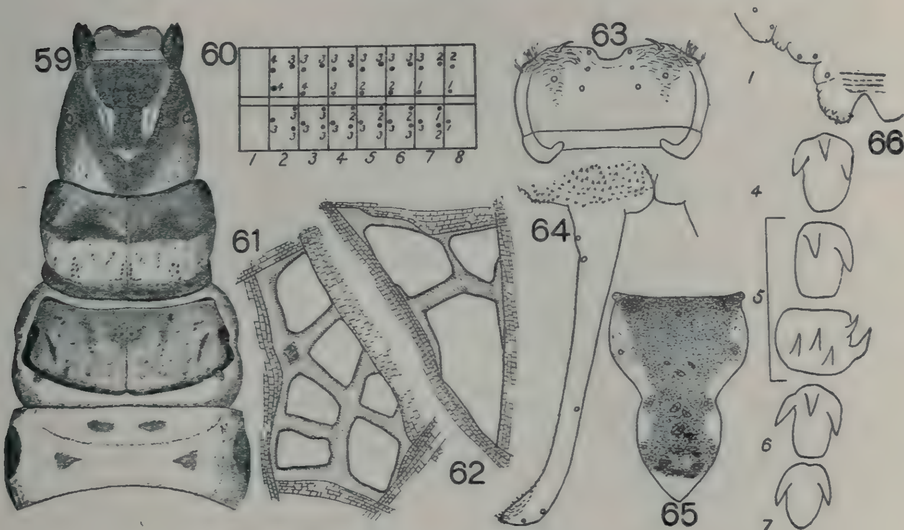
almost unbroken mass of moving cases, at first revealed not one inhabited larval or pupal case. They were not on the bottom, nor were they clinging to the vegetation, as is the habit of some species of the genus when pupating, nor were they under sticks or logs, nor in crevices. At last they were found deep down among the fibrous roots of sedge tussocks. Here they occurred in such numbers that they could be brought out by the handful from every tussock. Well hidden, as they were, their hiding places had been found by the muskrats of the region. Stumps and floating logs were piled by the rats with broken pupal cases from which the contents had been removed. Muskrat feces taken from these locations and disintegrated in water revealed enough chitinous fragments to indicate that the caddis-pupæ were an important article of diet at this season.

On emerging, the pupæ come to the surface and swim about, apparently blindly, until they encounter some suitable support projecting above the water, where, climbing a few inches above the surface, they transform. The greatest number of adults were on the wing during the middle of May. At this time swarms of them clung to every near-by bush, or, as dusk changed to darkness, flew over the pond.

Food of the Larvæ.—The larvæ eat vegetable matter, living or dead, with little discrimination for species or condition of preservation. They may readily be seen browsing on dead and decaying cat-tail or sedge, or on living plant tissue, or scraping loose fibers from submerged sticks. The stomachs examined contained particles of higher plant tissue in all stages of preservation, as well as many algæ, but decaying tissue was always in greatest abundance. The dominance of decaying tissue in the stomachs may be explained by a glance at their habitat during spring, before the period of pupation. At this time the pools are full of dead and decaying cat-tails and sedges; living plants are relatively rare. The algæ are apparently swallowed accidentally with the larger plants over which, in these pools, they form a thick scum.

Description of the Larva.—Length, when mature, 18—21 mm.; breadth, 3.5—4.5 mm. The color of the heavily chitinized parts is brown; the abdomen and weakly chitinized parts are white in young specimens, and rusty brown in individuals that are almost ready to pupate. The rust-like appearance of the weakly chitinized

parts of this larva is caused by a coating which can, with difficulty, be removed, leaving the skin white and revealing a sparse armature of very minute spines. The distribution of this rust-like coating




LIMNOPHILUS INDIVISUS.

59. Larva. Head and thorax.
60. Larva. Distribution of gills.
61. Sieve net. Front end of pupal case.
62. Sieve net. Caudal end of pupal case.
63. Larva. Labrum.
64. Pupa. Caudal appendage.
65. Larva. Frons.
66. Pupa. Chitinous plates of left side of abdomen.

is nearly uniform in different individuals and seems to be a secretion from the skin.

*Head.*—Marked above as in figure 59; the sides are light-brown without sharply defined marks, but, on caudal portion, bearing many small, inconspicuous muscle-attachment spots; the ventral side is uniformly light-brown, except the extreme caudal portion, which is crossed by the area of dark spots extending downward from the sides; the antennæ are jet black, except an area at the base, which is brown; the labrum (figure 63), is light-brown bordered with dark-brown; the mandibles are jet black, truncate, with fine teeth and a rather sparse brush of light-colored hairs on the edge of the groove; of these hairs the most cephalic are shorter and thicker.

*Thorax.*—The dorsal markings are shown in figure 59. The prothorax bears minute forward-pointing spines on its cephalic dorsal margin; its setæ are long, some equal to the length of the segment; a raised, black collar-like ridge extends from the base of the legs over the dorsum of the caudal margin of the segment, except at the median area, where it is broken; the ventral surface is white, except a brown spot which bears two darker marks near its caudal margin, and a small darker spot behind each leg; the fleshy horn is curved and well developed. The mesothorax is white beneath, with four dark spots near the caudal margin. The metathorax is white on the under side, with two broken dark marks.

*Legs.*—Brown, with darker margins, and armed with numerous long black setæ.

*Abdomen.*—The humps are well developed; the dorsal hump bears a pointed, finger-like process, and the lateral humps are rounded; groups of setæ occur at the sides of the humps; about six large setæ and several small ones occur on the ventral surface of the first segment; other segments do not bear large setæ on their ventral surfaces; segments 2 to 7 bear single small setæ on each side of the medium line above; segment 8 bears a row of about ten setæ across its ventral surface; segment 9 has an oval chitinous plate on the dorsum, which bears four large and many small setæ; each drag-hook has three small teeth at its base and is preceded by a chitinous plate bearing about ten setæ; a row of three large setæ occurs inside of each drag-hook and behind the chitinous plate; the lateral fringe is black and well developed; it extends from near the cephalic margin of segment 3 to the caudal margin of segment 8; above the lateral fringe on each segment occur minute, brown, paired spine-like processes; the gills are well developed; their number and distribution are shown diagrammatically in figure 60. The weakly chitinized portions of the entire larva are thickly set with minute spines.

DESCRIPTION OF THE PUPA.—Length, 13—17 mm.; breadth, 4—4.5 mm. In life the color of the thorax and appendages is brown, the abdomen is green, and the lateral fringe is deep black. The antennæ extend back to about the caudal margin of the eighth segment; they bear groups of short setæ on the dorsal sides of the second segments; each side of the labrum bears a group of about six long, hooked setæ; a row of sharp, curved forward-

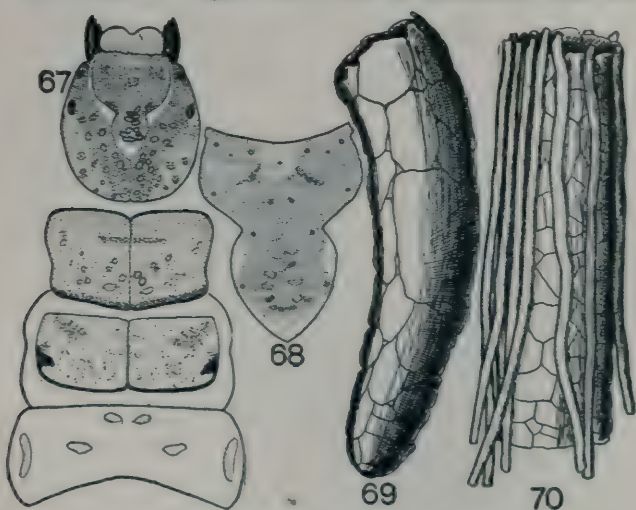
pointing spines borders the caudal margin of the eye; the second and third pairs of legs have well-developed swimming hairs and, in advanced pupæ, show the black spines of the adult conspicuously; the lateral fringe is well developed, commencing on the caudal margin of segment 5 and turning under the abdomen at the caudal margin of segment 8; the gills are well developed; the last segment bears a number of setæ and two backward-pointing processes (figure 64).

Description of the Case.—The length and breadth vary according to the material found in its environment. It is always bulky and is usually of the cross-stick type common in the genus. It may be made of bits of leaves or plant-stems or, sometimes, of seeds. When seeds are used it does not show the tendency to cross the material. The cavity is cylindrical and is always lined from end to end with a sheet of silk.

The case of the pupa differs from the larval case only in having the mesh of silk across its ends as illustrated in figures 61, 62.

## Limnophilus Submonilifer.

Habitat.—The larvæ are found in shallow water where there is an abundance of vegetation, often in situations that are com-




LIMNOPHILUS SUBMONILIFER.

67. Larva. Head and thorax.
68. Larva. Frons.
69. Case of mature larva.
70. Case of immature larva.

pletely dry during the droughts of summer. In the shallow edges of the Cove, in Bools' Backwater, and in most similar situations of the region, they are not uncommon dwellers.

HABITS.—Members of the species are bottom-crawlers, where their cases, closely resembling stems and grasses, are detected with no little difficulty.

Before pupating the larvæ wrap themselves securely, including their cases, in folds of the leaves of submerged plants or grasses. In this condition they are so perfectly concealed that their detection requires careful examination of every grass-blade.

FOOD OF LARVÆ.—Raspings from submerged sticks and plants form the food of the larvæ. In the raspings are found diatoms and other microscopic organisms, as well as wood and plant fragments.

If one watches a larva feeding upon a diatom-covered stick he will plainly see a trail of clean wood left behind the slowly moving larva.

DESCRIPTION OF THE LARVÆ.—Length, 15 mm.; breadth, 2.5 mm. The chitinous parts are light-brown, with a darker pattern of slight contrast, as shown in figure 67. Details of marking are subject to some variation in different specimens, but there is enough uniformity of pattern to make color characters of value in classification.

*Head.*—An ill-defined area of brown begins at the base of each mandible and extends back, adjacent or close to the margin of the frons and above the eye, to the caudal margin of the head; when this mark does not touch the frons, the area between it and the frons is almost colorless; each eye is located on the upper cephalic side of a light-colored circle; behind the eye the entire head is more or less marked with muscle-attachment spots; in front of this area the under surface is uniform brown. The frons (figure 68) is brown, with a light mark of varying size extending back from the median part of the cephalic margin, and a light-colored area behind the muscle-attachments spots; in some specimens the margins behind the constrictions are light-colored; the muscle-attachment spots are dark, but not strongly contrasting in color.

*Thorax.*—The prothorax is light-brown, margined with dark-brown or black, and with varying marks of brown (figure 67).

On the mesothorax the chitinous shield is pale-brown, with darker markings and black caudal margin terminating laterally in expanded black marks of varying extent; a broken dark mark is sometimes present on the cephalic margin. The chitinous plates of the metathorax are pale in color; the lateral plates are crossed by two dark marks.

*The Abdomen.*—On the ventral surface of the first segment there are a few weak setæ, which are not arranged in clusters. The gills are weak and are branched into a few weak filaments.

Description of the Case.—The case of the larva has the form of a cylinder about twenty millimeters long and four millimeters wide. It is made of vegetable matter of various kinds, according to the environment inhabited by the larva.

A common type of case is made of fragments of bark (figure 69). These cases generally curve slightly and taper toward the caudal end. The cephalic end is without a hood; the sides of the caudal end are drawn in to leave a small round opening.

When the larvæ live among cat-tails, or where large fragments are used, the curve of the case is less apparent, or may be entirely absent. Likewise the caudal end is less closed, or may be entirely open.

When living among roots, the larvæ often fasten root fibers along the sides of their cases (figure 70).

In preparing to pupate the larvæ roll their cases in dead leaves, or in grasses. At such times they are next to impossible to discover.

## Arctœcia Consocia.

Larval Habitat.—The larvæ occur locally in most streams of the region. They are more common in shallow water with a slight current, but they are also found in deep waters that are cool and well aeriated.

Habits.—In their manner of living the larvæ do not differ greatly from *Pycnopsyche* and its near allies, and, like them, the habit of changing the architecture and material of their cases from one type to another is frequently practiced. When time for pupation approaches, the larvæ usually hunt the seclusion of matted roots along the water's edge, or crevices in submerged logs or bark.

On one occasion several pupæ were found attached to roots

two to four inches above the level of the water. The water below was a spring pool which never rises to the level to which the larvæ had climbed. These pupæ were put in cages with no water, and successfully emerged about ten days later.

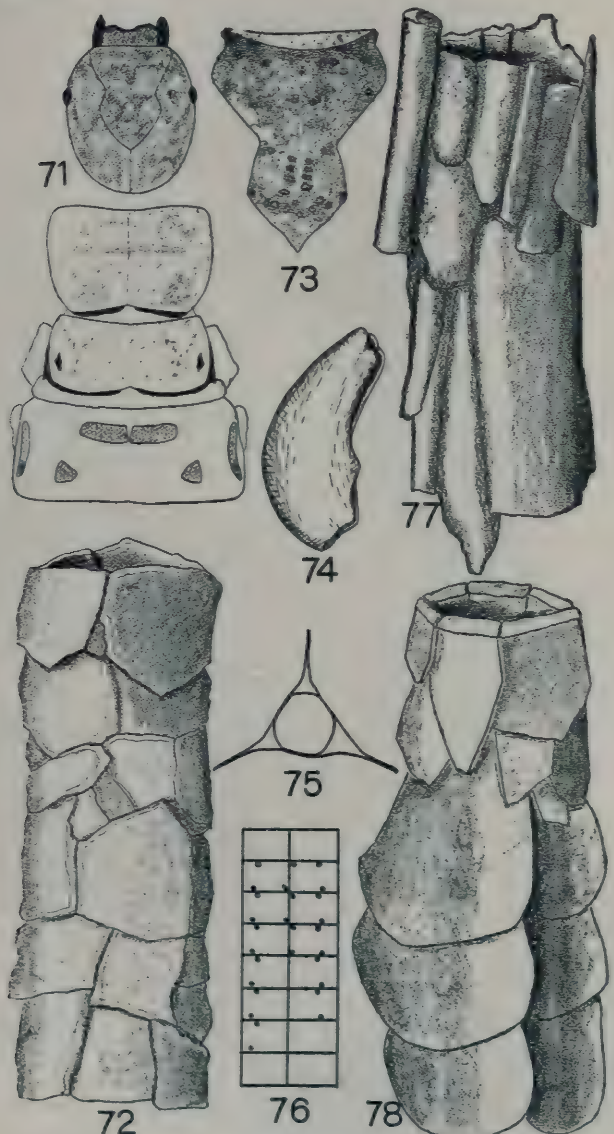
Food of Larvæ.—The larvæ feed on shallow raspings from the sticks and vegetation of the waters they inhabit. Stomachs examined contained a large amount of the outermost tissues of plants and sticks, together with about the same amount of sessile diatoms, and an occasional fragment of some minute crustacean, perhaps swallowed by accident.

Period of Emergence.—Specimens in captivity emerged during the latter part of June.

Description of Larva.—Length, 25 mm.; breadth, 4 mm. In attitude the larvæ maintain straight abdomens, slightly curved thorax, and head turned well under the first thoracic segment, with the mouth parts between the front legs. The coxæ are carried with their distal ends directed toward the median line of the body, which brings the bases of the tibiæ almost together.

*The Head.*—In color the head (figure 71) is light-brown, with very faint speckles of a shade darker over the dorsal and caudal portions; an unspotted area begins at the hind margins of the eyes and extends around the caudal portion of the ventral surface of the head. The setæ on the dorsal surface are deep-black. The frons is without pattern, except the faintly darker muscle-attachment spots. The mouth parts are often carried almost entirely telescoped within the cavity of the head; they have the general color of the head, except the mandibles, which are deep-black; in form the mandibles are broad and scoop-like, but slightly indented on the anterior margin.

*The Thorax.*—The prothorax has the dorsal furrow very feebly developed. In color the dorsal surface is pale straw-yellow with a few inconspicuous small specks of a slightly darker shade. The chitinous plate of the mesothorax is colored like the dorsal surface of the prothorax, its narrow caudal margin is conspicuously black, and there is a small, roughly triangular spot of black near each lateral margin, about midway between the front and hind margins. The deep-black coloring of the pleural suture is limited to a spot near the base of the coxa, and does not extend




ARCTOECIA CONSOCIA.

71. Larva. Head and thorax.
72. Case.
73. Larva. Frons.
74. Larva. Mandible.
75. Case. Cross section.
76. Larva. Distribution of gills.
77. Case.
78. Case.

back in a narrow line. On the metathorax the median chitinous plates are almost contiguous; the lateral plates are somewhat crecentric in form, and have a sparse growth of black setæ near the cephalic end.

*The Abdomen.*—On the first segment the dorsal hump is lacking; the lateral humps are well developed. The dorsal surface of the segment has a sparse growth of black setæ, which are not arranged in groups; the ventral surface of the segment bears a pair of light-colored chitinous plates, one each side of the median line behind the middle of the segment, each plate bearing a sparse line of short, dark-colored setæ along its cephalic margin; in front of these plates the cuticula bears a few irregularly placed setæ; at the base of each lateral hump, on the ventral side there is a pair of pale chitinous plates, the caudal plate the larger, each bearing a few setæ. The distribution of gills is represented in figure 76.

Description of the Case.—The species makes such a great variety of cases, of which different types so closely resemble the cases made by several other genera, that it is impossible to place any taxonomic importance on their architecture.

In a rough way the cases fall into two types—circular and triangular in cross section.

The triangular cases, made like the caudal part of figure 78, show the most distinct plan of architecture. From the exterior three sides are visible; each side is slightly convex, and is made of from three to six roughly oval sections of dead leaves. The cephalic end of each oval is fastened under the caudal end of the preceding oval. In cross section, figure 75, it is apparent that the outer triangle surrounds a thin-walled cylinder of leaf fragments, lined with silk.

In the cylinder type of case the larvæ sometimes make very neat structures of flat chips of stones, figure 72. In these cases the stone chips are neatly fitted and cemented together with a thin lining of silk. In cross section the cases are as nearly cylindrical as the size of the stones will permit. Besides these cases, which are built with a high degree of neatness, the larvæ sometimes make cases of twigs, fragments of bark, and debris of all sorts. These cases, of which figure 77 represents one of the most perfect, are among the most slovenly and carelessly-built cases inhabited by Limnophiladæ.

## Astenophylax Argus.

Habitat.—In most of the slow-moving, alder-bordered streams of the uplands the species is uncommon, but in Michigan Stream to the South, and Argus and Sphærium Streams to the East, they occur in the greatest abundance. In Michigan Stream their numbers are astonishing for a species of such size. Many hundreds of individuals live on a single rod of the small creek's bottom, and scores of pupæ can often be found clinging to a single root or stick.

Habits.—As might be expected under the uniform conditions of the spring-fed upland streams, the larvæ alter their habits but little during the changing seasons. In winter, as in summer, they crawl actively over the bottom, feeding and carrying on their usual activities. In both seasons the stomachs are equally gorged.

By the middle of April the larvæ have ceased their activities and have gathered and attached to their cases bulky, heavy material, large pebbles, chunks of bark, the large species of Sphæriidæ, *Sphærium simile,* or twigs, sometimes inhabited by the wood-boring Trichoptera of the genus *Ganonema.* These heavy cases are attached firmly by their cephalic ends to submerged logs, roots, or other solid supports. At this time the sieve-nets are spun. In *Astenophylax argus* the sieves are located within the tube a short distance from its caudal and cephalic ends. The mesh varies in size and form, but is roughly hexagonal.

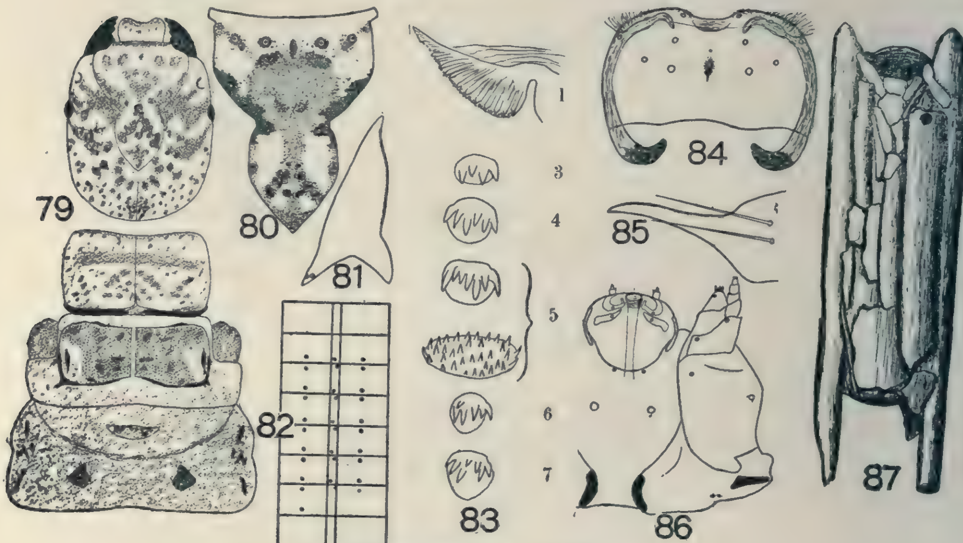
Food of the Larvæ.—The food of the larva throughout the year consists of dead bark and wood rasped from submerged twigs and logs. Specimens collected in February contained the same kind of food as specimens collected in mid-summer, and at both seasons the alimentary tracts were equally gorged.

Period of Emerging.—The time of emerging is confined to the first two weeks of June.

Description of the Larva.—Length of the mature larva is 50 mm. Its breadth at the third thoracic segment is 6 mm.

*Head.*—The head, except the mandibles, which are black, is brown, with inconspicuous darker markings, which vary somewhat in intensity in different individuals, but maintain the same general pattern for the species; the color-pattern and distribution

of setæ on the dorsum are shown in figure 79; the underside of the head lacks markings except an area of small, somewhat oval, well-defined spots, which project forward from its caudal margin on each side of the median line.




ASTENOPHYLAX ARGUS.

79. Larva. Head and thorax.
80. Larva. Frons.
81. Pupa. Mandible, lateral view.
82. Larva. Distribution of gills.
83. Pupa. Chitinous plates of left side of abdomen.
84. Larva. Labrum.
85. Pupa. Mandible, outer edge.
86. Larva. Lower mouthparts.
87. Case.

*Thorax.*—The color-pattern of the dorsum of the first and second segments is shown in figure 79; the under side is weakly chitinized, except for the horn on the first segment; the third segment above is weakly chitinized, except for a median glabrous spot near the cephalic margin, on each side of which there is a dark-brown mark, bearing five or six setæ; farther back and slightly more remote from the median line there is a triangular spot bearing about ten setæ; on each side of the segment there is an elongate glabrous area marked with several brown spots, the cephalic of which bears about a dozen setæ; the second and third thoracic segments bear numerous minute spines which, for the most part, point forward.

*Legs.*—Brown, with darker markings along the edges and around the setæ.

*Abdomen.*—The first segment above has several circular brown spots surrounding setæ, a glabrous area borders the caudal margin of each lateral hump, and a group of four or five fine setæ is present above and below each lateral hump; on the ventral side there are a few scattering setæ and a bilobed median mark, containing four or five setæ in each lobe; the entire surface of the first segment is thickly set with very minute spines. The lateral fringe of black hair begins near the posterior margin of the second segment and extends to the posterior margin of the eighth segment. The arrangement of gills is diagrammatically shown in figure 82. A slight variation of gills occurs on the caudal segments of different individuals.

Description of the Pupa.—Length, 30 mm.; breadth, 6 mm. The labrum is longer than broad, extending shelf-like over the mandibles and bearing a group of five long, dark-colored, hooked setæ on each side; two similar setæ, but not hooked occur on each side near the base, a shorter seta of lighter color points forward from the cephalic margin of each lobe and a similar seta occurs laterad from each pair of long basal setæ; the mandibles are straight, without teeth and sharply pointed, reaching not quite to the extreme of the labrum; each bears two setæ near its base; the dorsal part of the first abdominal segment is marked with small cross-folds, which give it a striate appearance, and is bordered behind with wing-shaped marks, somewhat striate and bearing numerous small thorns on their caudal margin, figure 83; the lateral fringe is black, commencing near the caudal margin of the fifth abdominal segment and forming a loop beneath the caudal margin of the eighth segment. The antennæ reach to the caudal margin of the sixth segment. The chitinous plates are shown in figure 83, but the number and arrangement of teeth is subject to variation in different individuals.

Description of the Case.—The larval cases, figure 87, the largest and most bulky in our streams, are constructed of fragments of twigs and bark, which vary greatly in size and shape. These fragments, arranged with little regard for system or symmetry, are fastened securely together by means of silk, and the

tube thus formed is lined from end to end with a tough cylinder of silk. Clumsy and bulky as the larval cases are, they do not vary greatly from cylindric form, nor do they have projecting twigs or corners that would catch during locomotion, nor chunks or stones that would be too heavy for the powerful larvæ to drag. In the pupal cases heavy stones and great fragments of bark are used, whose weight and form would make locomotion almost impossible.

## PYCNOPSYCHE SCABRIPENNIS.

HABITAT.—Specimens of this species were collected only in Sphærium and Argus Brooks; but the larvæ and cases are so similar to Halesus, and probably to other genera, that it is by no means probable that its distribution is as restricted as our data would indicate.

HABITS.—In the streams mentioned the larvæ are exceedingly abundant, crawling slowly over the bottom, or clinging with their heads pointing upstream, to submerged sticks and logs. In the latter position they sometimes completely cover sticks which are slightly above the stream's bottom, but upon the slightest jar they relinquish their holds and float down with the current.

Before pupation the larvæ leave the open water and hunt the seclusion of crevices in bark or root mats. At this time casual examination of the stream reveals not one larva in localities in which thousands previously formed the most conspicuous life on the bottom.

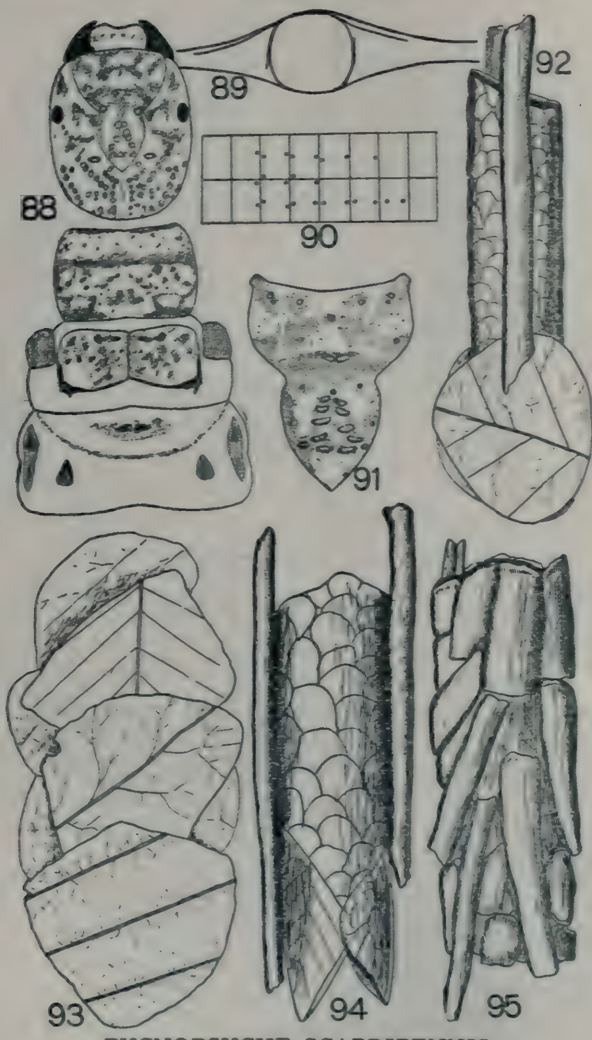
FOOD OF LARVÆ.—Stomachs examined contained only raspings of decomposed wood, much of which was ground to fine powder.

PERIOD OF EMERGING.—Adults appear during the last days of August and the first part of September.

DESCRIPTION OF LARVÆ.—Length, 25 mm.; breadth, 3.5 mm.

*Head.*—The head, figure 88, is large; in dorsal view it has almost parallel sides, slightly curved caudal margin and almost straight cephalic margin; in color it is straw-yellow, with a varying pattern of round or oval muscle-attachment marks, and shadings of dark-brown; on the ventral surface the brown muscle-attachment marks are confined to the caudal half of the head and

are bounded on each side in front by an oblique line of black muscle-attachment marks; between the oblique line of black attachment marks and the mouth parts there is shading of black and brown.




PYCNOPSYCHE SCABRIPENNIS.

| | | |
|---|---|---|
| 88. Larva. | Head and thorax. | 92. Case. |
| 89. Case. | Cross section. | 93. Case. |
| 90. Larva. | Distribution of gills. | 94. Case. |
| 91. Larva. | Frons. | 95. Case. |

The labrum is small, and about half the breadth of the cephalic margin of the frons.

*Thorax.*—The prothorax, figure 88, on its dorsal surface, has ground color of straw-yellow, slightly lighter than the head; it is shaded and mottled with dark-brown.

On the mesothorax the dorsal chitinous plates are mottled with dark-brown, except a circular area in each outer caudal angle, which is without mottling.

The metathorax has the median plates slightly separated, situated on a single plate-like area that is apparently more heavily chitinous than the surrounding integument of the segment. The plates of the second pair are uniform brown. The lateral plates are brown with dark marks at each end.

*Abdomen.*—On the first segment the spacing-humps appear as flat, brown, callous areas, which are but slightly raised above the surface of the segment; the cone-like form of the humps of *Halesus* is entirely absent. On the ventral surface, behind the middle of the segment, there is a pair of chitinous plates, each bearing about six setæ; in front of the middle of the segment there are a few scattered setæ.

The arrangement of gills is shown in figure 90.

Description of the Case.—The cases of *Pycnopsyche scabripennis* are subject to great variation in form. As a rule, the variation is seasonal—almost all of the cases are made on the same plan and undergo the same transitional change at the same time, but there are often a few specimens to be found that have omitted certain changes in their case-making. So one finds great numbers of specimens in a locality making cases of the same kind, but with careful search it may be possible to find examples of other types of architecture.

The first cases made by the species are usually flat, two-sided cases of leaf fragments, figure 93. In making this form of case the larva cuts round or oval fragments from sunken leaves. These pieces are cemented on the opposite sides of the cylinder in which the larva lives. At the cephalic end the upper leaf, or root, projects, hood-like, beyond the end of the tube; at the caudal end the roof covers the end of the tube, but the floor usually projects out even farther. Between the roof and the floor lies the tube in which the larva lives. It is made by cementing sides of small

leaf fragments between the broad floor and roof, and lining the cavity thus formed with a thin but tough sheet of silk. Figure 89 represents a cross-section of the case.

This type of case is used during the winter and spring months. It is the type most frequently omitted by the larvæ, perhaps because their environment does not always furnish suitable material.

Though the broad, flat form of these cases of leaf fragments, with their hoods projecting over the heads of the slowly-crawling larvæ, are as nearly invisible as is possible, it seems probable that their most important function is to form a broad surface that will always remain with the same side up, and not roll in the slow current.

As the larvæ get older, in late spring, they change the flat-leaf type of case to cases in which the tube is much tougher. Small fragments of bark are now mixed with pieces of leaves in the tube, the broad roof and floor of leaves is discontinued, and on each side of the case a heavy stick is added, which usually runs the entire length of the case and projects for half an inch beyond each end, figure 94. These "ballast" sticks have the same function as the flat surface of the leaf cases—they keep the cases from rolling in the current.

In changing the case from the flat-leaf type to the ballast-stick type, the sticks are added to the top and bottom of the leaf case, causing the sides of the leaf case to become the top and bottom of the ballast-stick case. Figures 92 and 94 represent the transition between the flatleaf case and the ballast-stick case.

When the time for pupation draws near the larvæ of Pycnopsyche, like several other species that use ballast sticks, cut away the ballasts and make rough cases of irregular construction, in which there is no difference between top and bottom, figure 95. When the case is made fast for pupation there is no longer need to make other provision against its rolling in the current.

## Platyphylax Designata.

Habitat.—The larvæ are abundant in the Big Springs of the McLean basin, and occur in less abundance in several of the nearby springs and spring streams. All of the waters in which the larvæ have been found are cold throughout the summer and never freeze in winter. It was in similar springs in Wisconsin that Vorhies first found the larvæ.

Although, in the Cayuga Basin, the larvæ have been found only in the McLean region, careful collecting probably will reveal their presence elsewhere, for the adults are not uncommon in several localities of our uplands.

HABITS.—During the daytime some larvæ can always be found crawling over the bare stones of the springs they inhabit. More larvæ, however, are to be found attached to the under-side of sticks and stones. These larvæ, like other species of Limnophilidæ, are nocturnal, except, perhaps, when newly hatched from the egg. On this subject Vorhies, '05, makes the following interesting observation: "The interesting fact was noticed that these newly-hatched larvæ are positively heliotropic to a marked degree when on a dry surface, but at once become negatively heliotropic when placed in a dish of water. The necessity of getting out from beneath stones where the eggs are placed in order to find water, and of getting beneath stones for protection while building a case, after reaching it, offers an explanation for this peculiarity."

In preparing to pupate, unlike the common method of the family, the cases of this species are not attached to any object, but lie on the bottom of the stream, sometimes under stones and sticks, sometimes on the surface of the gravel, but always with the head directed upstream. In one habitat of the species the bottom is of rather soft muck. In this spring the pupal cases were always buried under an inch or more of soil.

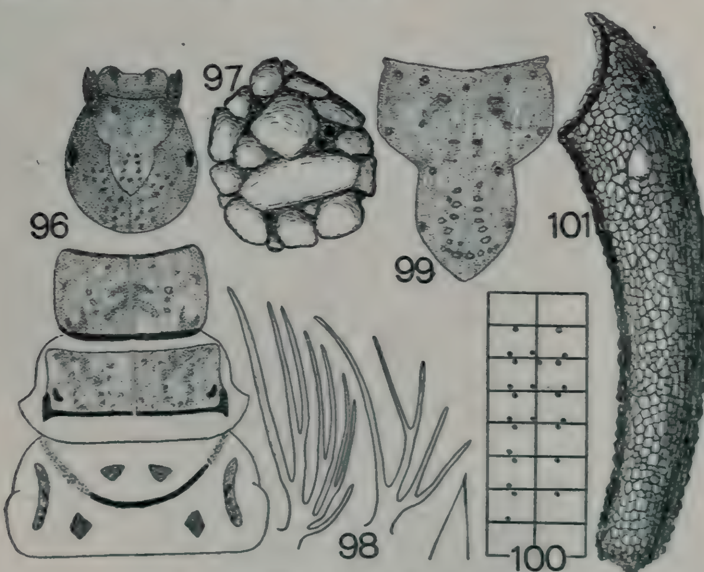
Prepupæ and pupæ can be found in every season of the year, unless, possibly, the early months of winter. Their greatest abundance, however, comes during late winter and very early spring.

FOOD OF LARVÆ.—To determine the food of the larvæ, about six stomachs of mature larvæ, and as many of young larvæ, were examined. The stomachs of the young larvæ contained only diatoms, mixed with a large amount of sand—the sand amounting to many times the bulk of the diatoms. The stomachs of the old larvæ contained about the same mixture of sand and diatoms, and also a few fragments of higher plants. Vorhies, '05, found the food of the old larvæ consisting of water-cress and water-milfoil, and in 1909 states that the young larvæ feed upon diatoms. In the springs of the McLean region there is a very sparse growth

of higher plants, which probably forces the larvæ to feed upon diatoms throughout their lives.

Period of Emerging.—The species is on the wing in greatest numbers about the middle or latter part of April, but late comers have been found in our locality until the latter part of August, and Vorhies, in Wisconsin, found several egg masses on October 12th, and one egg mass as late as November 2d. Our first specimens were taken on bright days during the very first part of April, when snow in nearby drifts was still piled to a depth of several feet. At such times the adults are not uncommon.

In leaving the cases the pupæ sometimes follow the usual method of breaking through the end of the case. More often, however, they tear out a section of the side wall, leaving a long, jagged hole in the side of the case.




PLATYPHYLAX DESIGNATUS.

96. Larva. Head and thorax.
97. End of pupal case.
98. Larva. Gills.
99. Larva. Frons.
100. Larva. Distribution of gills.
101. Case.

Description of the Larva.—Length, 18 mm.; breadth, 4 mm. In life the body is light-green in color. In form it is distinctly curved, and apparently incapable of straightening.

*The Head.*—Deep mahogany-brown; in some specimens so dark that the pattern is visible only in the best illumination, figure 96. The pattern is very slightly darker than the ground color of the head. On the frons, figure 99, the muscle-attachment spots are the only marking, but the ground color gradually becomes darker toward the mouth-parts. The head, in front of the eyes, is without markings; behind the eyes, on the dorsal, ventral and lateral surfaces, there is a mottling of small spots, slightly darker than the ground color. Each eye is bordered on its lower side by a crecentric mark of light color.

*The Thorax.*—The pronotum is of lighter color than the head; its pattern is shown in figure 96; on the under-surface there is a median dark mark near the caudal margin; the horn is dark-brown. On the mesothorax the dorsal chitinous plate has the same ground color as the pronotum. It is bordered along the hind margin by a narrow line of deep black, which widens at the angle with the lateral margin and extends about half way up the sides; on each side of the chitinous plate, opposite the end of the black marginal stripe, there is a small, deep, black mark, which sometimes blends into the black marginal line; on each side of the median ventral line, near the caudal margin of the segment, there is a curved line of about five small round chitinous spots. On the dorsal surface of the metathorax the median chitinous plates are separated by about the breadth of one of the plates; the lateral plates are somewhat crecentric in form, with a sparse growth of setæ on the cephalic third; behind these setæ the plates are marked with black.

*The Abdomen.*—The dorsal hump on the first segment is well developed and pointed—the lateral humps are rounded; on the ventral surface there is a broad, raised area covered with an evenly-distributed growth of black setæ. Each gill arises from a single stem and branches biramously on a single plane, figure 98. The distribution of gills is diagrammed in figure 100.

Description of the Case.—The typical case of the larva, figure 101, is made in the form of a slightly-curved cylinder, tapering gradually toward the caudal end. On the outside of the curve of the cylinder, at the cephalic end, there is a tapering hood which extends over the head of the larva, completely covering all but the legs. These cases are made of grains of coarse sand of nearly uniform size, and are lined with a tough, but brittle, sheet of silk.

In the habitat where the bottom is of muck the larvæ use small chips of bark in the structure of their cases, making them as nearly the typical form as the nature of the material at hand will allow.

The case of the pupa is like the case of the larva, except that there are pebbles of large size grouped around and over the front end of the case, giving it a rounded form. The opening at the caudal end of the case is covered and rounded with pebbles of about the same size as those of the larva's case. At each end the case is perforated through the silk lining between the pebbles, by from one to six round holes, figure 97.

The pupæ cases from the mucky situation had many small molluscs fastened to the cepahlic end.

## Halesus Guttifer.

Habits.—Larvæ are common in Michigan Streams below the swamp, and have been taken in Spencer Lake. It is probably a common species in many of our ponds and slow-moving streams.

In habits the larva does not seem to differ from *Pycnopsyche scabripennis,* but it has not been so well studied.

Before pupation the larvæ attach the cephalic end of the case to the under-side of a submerged log, or within some crevice of wood or bark.

Food of Larva.—Fine raspings of decomposed wood seem to be the only food of the larvæ.

Period of Emerging.—Specimens in captivity emerged during August and September. Wild specimens have been taken on the wing as late as November.

Description of Larva.—No constant characters have been found that will distinguish between the larvæ of *Pycnopsyche scabripennis* and *Halesus guttifer,* except the size and form of the spacing humps. In *H. guttifer* the dorsal and lateral humps are well developed; the dorsal hump is cone-like, terminating in an acute nipple-like process.

The description of other parts of the larvæ of *Pycnopsyche scabripennis* will apply equally well to *Halesus guttifer.*

Description of the Case.—*Halesus guttifer* makes ballast-stick cases and irregular prepupal cases, which are not distinguish-

able from those of *Pycnopsyche scabripennis,* figures 92, 94. The species has not been observed during the early season to ascertain whether it makes the flat-leaf type of case.

## PLATYCENTROPUS MACULIPENNIS.

HABITAT.—The larvæ live in spring-fed streams, where the water is clear and cold, and where the growth of vegetation is sparse or wanting. In limited numbers they are found in parts of Bool's Brook, but in the streams of the McLean Basin, especially in Argus Brook and the upper regions of Sphærium Stream, they are among the most common caddis-worms.

HABITS.—The larvæ are bottom dwellers in streams with gentle current, and without dense growth of vascular plants. In such streams they are evenly distributed, apparently never congregating in certain areas, as do the larvæ of many other species.

Before time for pupation the larvæ attach their cases to submerged sticks or roots, or hide in the crevices of bark or wood.

FOOD OF LARVA.—No studies have been made of the food of the larvæ.

PERIOD OF EMERGING.—Adults appear during the middle of July.

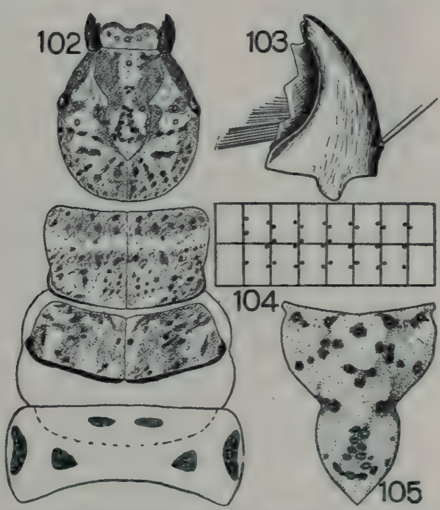
DESCRIPTION OF LARVA.—Length, 22 mm.; breadth, 4.5 mm.

*Head.*—The ground color is straw-yellow, shaded and spotted with brown, as in figure 102; on the under-surface there is an area of nearly round spots on the posterior part of each gena, in front of the spotted area each gena bears a single elliptical coalesced pair of muscle-attachment spots. Each mandible, figure 103, bears a line of yellow hairs on the upper margin of the inner side. The labrum has the straw-yellow ground color of the head, but is margined with brown and has a brown spot near its center.

*Thorax.*—The prothorax, figure 102, is light-colored, profusely spotted with brown. On the mesothorax the chitinous shield is smoky-brown, with numerous dark spots, except an area near each outer margin where the smoky appearance is absent; the black caudal margin of the shield widens at the corners into a broader mark, which has a constriction in the middle. The mesothorax, on its dorsal surface, is creased by a well-marked furrow, which

passes around the median plates; the median plates are narrow and are separated by not more than the length of a single plate.

*Abdomen.*—The spacing humps are flattened; the dorsal hump is surrounded by numerous scattered setæ, which are not grouped in clusters; on the ventral surface of the segment there is a lip-like elevation of the cuticle, which bears a pair of large setæ rising from dark-colored punctures; in front of the folds the setæ are scattered over the ventral surface of the segment with no tendency to form clusters; the distribution of gills is diagrammatically shown in figure 104; each gill has, typically, three branches, except on the last two or three gill-bearing segments, where the number of branches is reduced to one or two and the gills themselves are weaker.




PLATYCENTROPUS MACULIPENNIS.

102. Larva. Head and thorax.
103. Larva. Mandible.
104. Larva. Distribution of gills.
105. Larva. Frons.

Description of the Case.—Length, 20—25 mm.; breadth, 7—10 mm. The larvæ make cases of the typical cross-stick type, selecting twigs or grasses of smaller diameter than is usual in the genus Limnophilus, and cutting off the loose ends close to the case, thus forming a case of more cylindrical and compact appearance than is usual in this type of case.

At the caudal end of the case the walls are drawn abruptly over, leaving a small circular opening to the tube.

## Chilostigma Difficilis.

Habitat.—The larvæ of the species have been found in a very limited area of Argus Stream, in the McLean swamp. The stream is a small one, hardly more than a foot in width and three or four inches in depth. It rises in a sphagnum bog and penetrates a dense thicket of alder for about a half mile, when it enters a larger stream. Through the alder thicket the waters are in deep shade, and leaves and sticks litter the bottom. In this portion of the stream, so far as we can see, there are no differences of conditions within its waters. Yet this species, for the three years we have known it, has inhabited an area of the stream not more than a hundred yards in length. In this limited area it occurs in great numbers.

Habits.—Until the middle of summer is past these larvæ rest or crawl slowly about over the bottom of the stream. As the period for pupation approaches they congregate in great numbers on submerged sticks or roots. Often they occupy every available lodging space on a certain stick, while other similar sticks of the neighborhood are left entirely free from their presence. Only the front ends of the cases are attached to the support, from which they project at all angles.

Food of the Larvæ.—Stomachs examined contained quantities of fragments of wood and leaves, nothing else.

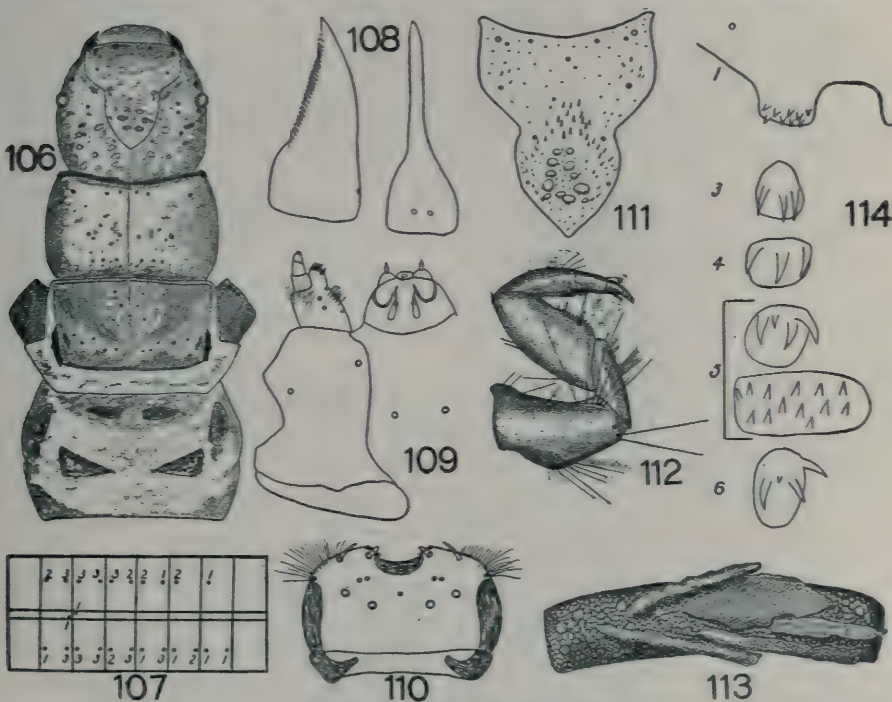
Period of Emerging.—Specimens in captivity emerged during the first half of October, but it is probable that under natural conditions they emerge throughout a longer period.

Description of the Larva.—Length, 16 mm.; breadth, 2.5—3 mm.

*Head.*—The color is light-brown, figure 106, almost uniform, except the dark muscle-attachment circles and a thick stippling of microscopic spots; the dorsal surface, especially the frons, figure 111, bears numerous pointed, spear-like processes, which are plainly evident in balsam mounts. The labrum, figure 110, is brown, with a darker mark behind the middle of its front margin; the innermost setæ on its front margin are short and blade-like; the outer setæ of the front margin are longer, but blade-like; other setæ of the labrum are indicated by circles in the accompanying

drawing. The mandibles are black, with a line of dense yellow hair on the top edge of the groove.

*Thorax.*—The prothorax is light-brown with a slightly oblique black mark on each side above the coxa; the top surface has, in




CHILOSTIGMA DIFFICILIS.

106. Larva. Head and thorax.
107. Larva. Distribution of gills.
108. Pupa. Mandible.
109. Larva. Lower mouthparts.
110. Larva. Labrum.
111. Larva. Frons.
112. Larva. Front leg.
113. Case.
114. Pupa. Chitinous plates of left side of abdomen.

addition to numerous setæ of the ordinary type, many shorter, spear-shaped, forward-pointing spines, not shown in the accompanying figure; these are most numerous along the front margin, where they project over the base of the head; the dorsal markings of the meso- and meta-thorax are shown in figure 106. The legs are light-brown, margined and marked with black. Figure 112 shows a front leg.

*The Abdomen.*—The lateral fringe is short and weakly devel-

oped; it extends from the front margin of the third segment to the hind margin of the eighth segment. The distribution of gills is diagrammatically shown in figure 107.

Description of the Pupa.—Length, 10—11 mm.; breadth, 2—2.5 mm. The antennæ extend back almost to the tip of the abdomen. Each side of the upper surface of the labrum bears a group of about five long, black, hooked setæ. The mandible is shown in figure 198. The lateral fringe begins near the hind margin of segment five and curves under the hind margin of segment eight; it is black in color and is much better developed than that of the larva.. The last segment bears a pair of fleshy appendages. The chitinous plates of one side of first and third-seventh abdominal segments are shown in figure 114.

Description of the Case.—The case of the larva, when mature, is 15—20 mm. long; its diameter is 4 mm. or more at the cephalic end, according to the kind of material used in its construction. In form it is cylindrical and slightly curved. The larvæ, during their active period before pupation, construct their cases largely of quartz sand, but usually have a greater or lesser number of bark chunks around this inner cylinder. Sometimes, however, these bark fragments are almost, or even entirely, lacking. In preparation for pupation the larvæ usually remove almost all of the plant fragments from their cases. They then congregate in numbers on some support, as a submerged stick or root. Before pupation takes place the two openings of the case are stopped with small grains of sand firmly cemented in place. Apparently there is no mesh left open. Figure 113 represents a typical larval case of quartz sand and a few fragments of bark.

## Genus Neophylax.

*Head.*—The head is very long and narrow, held pointing backward with the under-side against the under-side of the thorax when at rest.

*Thorax.*—The prothorax is narrow and lacks the "horn." On the mesothorax the chitinous plates above the coxæ extend back until they meet the dorsal plates.

*Abdomen.*—A transverse elliptical ring marks the under-side of segments three, four, and five.

The genus offers many unsolved problems, such as the function of the gill-like structures on the first abdominal segment in certain species, and the morphological changes that take place during the long prepupal period.

The Case.—In length the case, figure 120, is about 13 mm. It has the form of a cylinder, made of fine sand grains, tightly cemented with tough, brittle silk. The cylinder is slightly curved toward the ventral side. Along the sides of the case there are several flat ballast stones.

In the prepupal or pupal state, the condition in which the cases are almost always found, the ballast stones are larger than those used during the active period, and each end of the cylinder is capped with a large pebble, figure 119.

Larvæ of at least two undescribed species were collected.

## Neophylax Concinnus.

Habitat.—The species, in the immature stages, is common in the riffles of most upland streams of the region, such as Sphærium Stream, Michigan Stream, and many others. It does not seem to occur in spring basins; nor is it common in the warm water of the lowlands, though a few specimens have been found in Cascadilla Creek and in Coy's Glen.

Larval Habits.—During the winter and early spring the larvæ crawl over the stream's bottom, feeding and storing up fat to carry them over the long prepupal period, lasting through the entire summer. As spring advances they seek the support of some solid object, such as a submerged rock or log. Here the cases are firmly attached, often great numbers of them on a single rock, with the bodies parallel, like cords of wood.

In late spring, when the larvæ have attained full size and have attached their cases to some solid object, the sieve nets are spun across the ends of the cases, and the prepupal state begins.

In sealing the case the larva does not cover the ends with a silken mesh, as do other species of the family, even when flat stones also are used. Neophylax selects a stone for each end of the case that is slightly larger than the diameter of the tube. These stones are tightly cemented over the ends of the case with thick sheets of cement-like silk. On the ventral surface of the cephalic

end the sand of the tube is cut away in semi-circular form and the opening thus formed is covered with a lattice-like arrangement of heavy rods of silk, figure 119. This end of the case is held above its support by a short stalk of silk. At the caudal end of the case a semi-circular opening is not made, but the lattice-like silk rods are made between the end rock and the ventral surface of the tube. Usually the rods are overlapped by the edges of the case and are invisible from the outside.

During the long prepupal period, lasting several months, from late spring until the latter part of August, the larvæ remain quiet with their heads folded between their legs. During this period they are incapable of taking any food, and dissection shows the alimentary canal entirely void of material of any kind.

If, during this period of helplessness, the stream recedes enough to dry the cases, the larvæ perish, unable to reach the water, which may be but a fraction of an inch below.

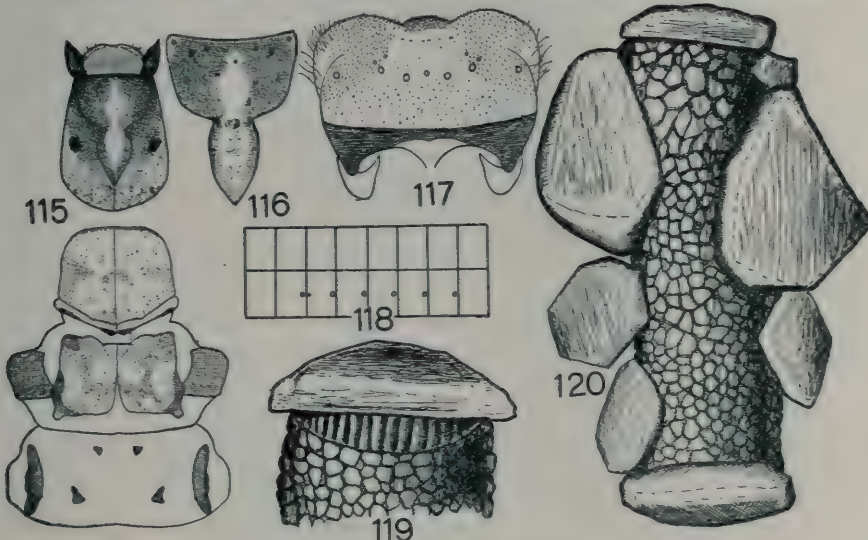
Period of Emerging.—Adults emerge about the end of the first week of October, and continue on the wing until the middle of November. They are weak flyers and do not wander far from the stream's edge.

Description of Larva.—Length (in natural position, with head turned under thorax), 8—10 mm.

*Head.*—In form, the head, figure 115, is long and tapering from the eyes to the mouth parts, and quite abruptly rounded behind the eyes. The frons, figure 116, seen in profile, has a decided mound-like prominence at the point between the two eyes. In color, the dorsal surface of the head bordering the frons is dark-brown, almost black on the cephalic portion, but becoming lighter as it progresses back; the frons is dark-brown, except an irregular mark of light color, figure 116; behind the dark mark bordering the frons the head is irregularly spotted with light-brown; the sides of the head are light-brown, except a narrow area surrounding each eye, which is almost white; on the under side of the head there is a broad mark of brown, which gradually shades into the light color of the sides, except along the cephalic margins, where it is narrowly connected with the dark color of the dorsal surface.

*Thorax.*—The prothorax above, figure 115, is light straw color,

with a dusky border along the cephalic margin and dark mottling on the caudal half; on the under side there is a chitinous plate of dark-brown color in front of the caudal margin of the segment.




NEOPHYLAX CONCINNUS.

115. Larva. Head and thorax.
116. Larva. Frons.
117. Larva. Labrum.
118. Larva. Distribution of gills.
119. Respiratory openings of pupal case.
120. Pupal case.

On the mesothorax the chitinous plates above the articulation of the coxæ extend up to the lateral margins of the dorsal shield, with which they are narrowly united; on the under side of the segment there is a pair of chitinous plates in front of the caudal margin; the dorsal plates, figure 115, have a varying pattern of dark-brown on a lighter field.

*Abdomen.*—On the first segment the dorsal hump is represented by an elongate chitinous plate; the lateral humps are prominent and of darker color than the surrounding cuticle; on the dorsal surface there is a line of sparse setæ passing in front of the dorsal hump and ending well above the middle of the lateral humps; on the ventral surface there is an elevation which bears a pair of small chitinous spots, each with a single seta; midway between this elevation and each lateral hump there is a thumb-like structure of doubtful function. On the ventral surface of seg-

ments three, four, and five, there is a transverse elliptical ring of chitin. The gills, figure 118, are weak and of varying number.

Description of the Case.—The case of the mature larva is about ten millimeters in length. It is constructed of small or minute sand grains, firmly cemented together in the form of a slightly flattened and slightly curved tube. On each end of the tube the larva cements one or more heavy "ballast" stones, figure 120.

## Neophylax Automnus.

Larval Habits.—The larvæ are found in spring basins and in spring streams near their sources. In the McLean region they are especially abundant in Big Spring and its outlet for a few hundred feet. They do not seem to occur in streams far from their sources, nor have they been found where there is any great inflow of surface water. These spring streams, in which the larvæ occur, are swift-flowing, with stony bottoms, and practically void of vascular plants and of sticks and surface litter.

Larval Habits.—In habits the larvæ do not seem to differ from *N. difficilis.*

The prepupal behavior, also, is apparently like that of *N. difficilis.*

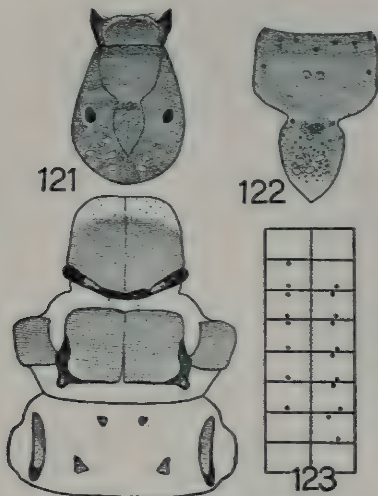
Period of Emerging.—Adults are on the wing from late September until early November.

Description of Larva.—Length (in natural position, with head turned under thorax), 7 mm.

*Head.*—In form the head, figure 121, is similar to that of *N. difficilis,* except that it is narrower across the cephalic margin. In color it is deep mahogany-brown, almost black, except a light-colored semi-circular area around the under surface of each eye, and some small light-colored spots behind and beneath the eyes. On the frons, figure 122, there is a thorn-like projection that is plainly visible in profile view.

*Thorax.*—The cephalic third of the prothoracic shield, on the dorsal surface, is creamy white; behind this light area it is dark smoky-gray. The mesothoracic shield is smoky-gray with indistinct markings, and bordered on the lateral and caudal margins with black, as in figure 121.

Description of the Case.—The case differs from that on *N. concinnus* only in its slightly smaller size, and in the smaller number of the "ballast rocks" used during the prepupal condition. The manner of sealing the case before pupation does not seem to differ from that of the previous species.




NEOPHYLAX AUTOMNUS.

121. Larva. Head and thorax. 123. Larva. Distribution of gills.
122. Larva. Frons.

## FAMILY SERICOSTOMATIDÆ.

The family, as it now stands, consists of four widely-separated subfamilies. No group characters have been found that will satisfactorily include the larvæ of these subfamilies and exclude members of other families.

The same evidence of distant relationship prevails in the habits as in the classification. For this reason no attempt is here made to discuss the family as a whole, but the known local species will be described and discussed under their separate headings.

### Helicopsyche Borealis.

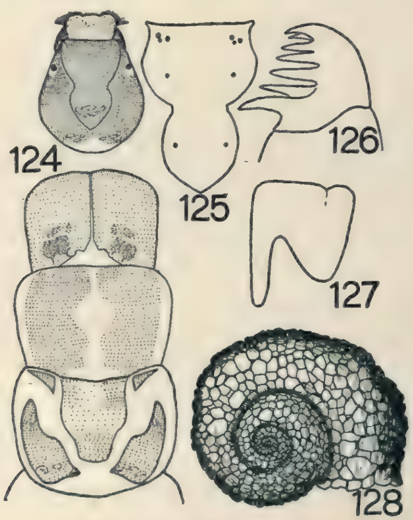
Habitat.—The larvæ are found in almost all stony streams of the region, and also occur on the rocks of exposed shores of Cayuga Lake. Vorhies, who studied the Trichoptera of both streams and lakes in Wisconsin, found the larvæ only in the lakes.

In view of this discrepancy in habitat, and also in the difference of size of both adults and larvæ, it seems probable that there are more than one species in the genus. Dr. Betten, however, after careful study of a large number of adults, could find no characters for distinction, except size, and recognizes but one American species in the genus.

HABITS.—In many of the streams about Ithaca the larvæ are very abundant, but are difficult to discover during larval life, while they live among the sand and gravel of the stream's bottom. Shortly before pupation they attach their cases firmly to some submerged rock or log, usually selecting a rough surface. At this time they often display a gregarious instinct, large numbers congregating within a very small area. It is during the prepupal and pupal periods that they are most often collected.

PERIOD OF EMERGING.—Adults emerge from the latter part of June until the end of July.

DESCRIPTION OF LARVA.—Length, 6 mm. The larva, when removed from case, assumes a spiral position of at least one and a fourth turns.




HELICOPSYCHE BOREALIS.

124. Larva. Head and thorax.
125. Larva. Frons.
126. Larva. Drag-hook.
127. Larva. Chitinous support, middle leg.
128. Case.

*Head.*—The dorsal surface of the head, figure 124, is dark-brown, except along the margins of the frons, where there is a very narrow light line which broadens at the constriction of the sclerite; there is also a light-colored area in front of the caudal margin of the head, and a light circular area surrounding each eye. The caudal third of each side of the head has numerous light-colored muscle-attachment marks. On the ventral surface the head is white, with several conspicuous dark-brown muscle-attachment marks on each side of the gula.

*The Thorax.*—The pronotum, figure 124, is brown, with a varying pattern of light and dark marking; on each side of the segment the chitinous support for the leg has a deep notch, figure 127, into which a tongue-like extension of the coxa hinges.

*Abdomen.*—On the first segment the dorsal hump is absent, and the lateral humps are but slightly raised and are thickly covered with minute spines, arranged in pairs. Gills and the lateral fringe are absent. The drag-hooks bear several long teeth, figure 126, giving each hook a fan-like shape.

The abdomen is curved to fit the form of the case, as the insect lives with its ventral side toward the axis of the whorl.

Description of the Case.—The well-known spiral case, figure 128, quite closely resembles some of the fresh water molluscs, for which it has been more than once mistaken and described. It is made of minute sand grains, securely cemented together. The tube in which the larva lives is broadest at the mouth and tapers gradually to the tip.

Though the mollusc-like case of the genus Helicopsyche is a unique plan of architecture, it is not such a wide deviation from the cases of other Trichoptera as appears on first sight. Apparently the larva starts its case in somewhat the form of a minute horseshoe and, continuing the cephalic end around the caudal end, builds on until the spiral form is reached, ever-increasing the diameter as it builds around the circumference.

Such a case would be made by a species that makes a cornucopia-shaped dwelling, such as *Leptocerus ancylus,* figure 167, if the bend in its case were very greatly increased and the tube slightly elongated.

Before pupation the case is tightly glued to some solid support and the cephalic end is closed by a convex lid of silk, with a

split-like respiratory opening on the side toward the axis of the whorl. Behind the caudal end of the pupa a flat sheet of silk with several respiratory openings crosses the interior of the case.

## Goera Calcarata.

Habitat.—The larvæ are found in riffles of the large streams of the region, both in the uplands and near the lake's level. They also occur on stones in wave-beaten areas on Cayuga Lake's shore.

Habits.—Little has been learned of the habits of the larvæ, beyond the fact that they are found crawling over the surfaces of bare, current-swept rocks from late summer until the end of March, when they attach their cases firmly on the exposed edges of stones, together with *Psilotreta* and a few other species of the rapid waters.

Period of Emerging.—Adults emerge during the last week of April and the first week of May.

Description of Larva.—Length, 10—12 mm. There is a heavy chitinous spur above each mesothoracic leg, grooved on its cephalic margin to fit a groove on the lateral margin of the pronotum.

*Head.*—The back part of the head, figure 129, on the dorsal surface, is flattened and slopes toward the caudal margin; in front of this flattened area, whose boundary passes in front of the eyes, the head is cone-shaped, sloping toward the mouth-parts. In color the entire head is uniform black-brown, except a slightly lighter circular patch surrounding each eye.

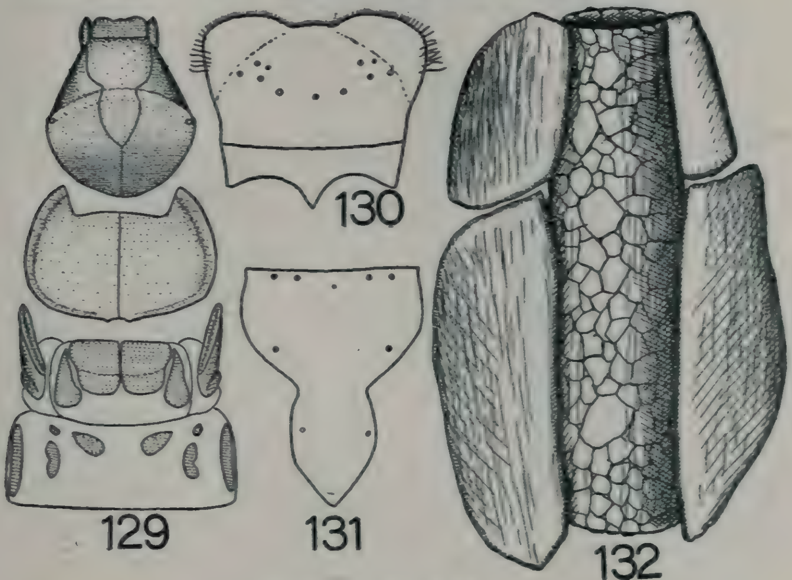
*The Thorax.*—The pronotum, figure 129, is very heavily chitinized. The cephalic margin is inset so that the lateral margins extend forward in sharp points. The lateral edges are thick and deeply grooved, apparently to fit the grooves of the heavy chitinous spurs of the mesothorax.

On the mesonotum there are two pairs of large chitinous plates, figure 129. Above each mesothoracic leg there is a very heavy chitinous spur, grooved on its cephalic margin, which projects well beyond the cephalic margin of the segment.

The metathorax bears four pairs of chitinous plates, figure 129.

It is to be observed that in the European fauna the genus Gœra has two pairs of plates on the mesonotum and only three pairs on the metanotum, while the genus Silo has four pairs of

plates on the metanotum, but has three pairs on the mesonotum. Thus *G. calcarata* seems to fall in neither of these genera. The adult, however, seems to agree best with the genus *Gæra*.




GOERA CALCARATA.

129. Larva. Head and thorax. 131. Larva. Frons.
130. Larva. Labrum. 132. Case.

*The Abdomen.*—On the first segment the dorsal hump is well developed; the lateral humps are present, but flattened. Branched gills and the lateral fringe are present. The drag-hooks are stout and bear but a single spur.

Description of the Case.—The case, figure 132, has the form of a tube of fine sand grains. The tube is very slightly bent and is slightly flattened on the ventral side. Fastened to each side of the tube are heavy ballast stones—usually two to each side.

Before pupation the larva places a stone over the opening at each end of the tube. Across the face of each stone a solid sheet of silk is spun. In the crevices between the stone and the tube a series of elongate respiratory openings are left. The case is fastened to its support by a stalk of silk at each end.

The preparation for pupation, like the form of the case, is very similar to those of Neophylax.

## Brachycentrus Nigrisoma.

Habits.—During the first six weeks of their lives the larvæ are active, crawling about in quiet eddies along the banks of the stream in search of food. After this period they move to the center of the stream and live sedentary lives, with one edge of the large end of their cases firmly cemented to submerged rocks or sticks. Always they inhabit positions on the exposed surface of their support and always they face the unbroken current. While waiting for prey they assume the position shown in figures 142 and 144, protruding their heads slightly and extending their prothoracic legs straight forward. The mesothoracic legs are held upward while the metathoracic legs are extended to the sides. From this position they eagerly seize and quickly devour small larvæ or bits of vegetation that float within their grasp.

In the unnatural conditions of still-water aquaria in the laboratory they attach their cases and assume their characteristic attitude of outstretched arms. If a particle of food material be moved within their grasp it is eagerly seized and devoured, but if, however, the food be placed in front of the larva, even in contact with its limbs or jaws, it is ignored or pushed aside. Apparently the larva does not recognize food that is not moved into its grasp. From time to time larvæ confined in aquaria detached their cases and moved from place to place. It seems probable that the larvæ in the streams, also, at times move about in search of building material, for it is unlikely that chance would place enough suitable case-building material within their reach.

Larvæ which were put in the water after they had been exposed to the air until the moisture had dried from their cases, which accordingly floated, swam with their legs motionless and in the attitude assumed while waiting for prey. Their motion through the water was caused by the respiratory current being forced through the small openings at the caudal ends of their cases, somewhat after the manner of locomotion of certain dragonfly nymphs. This was probably an unnatural mode of locomotion, never practiced in nature, at least not by this species.

In preparation for pupation the larva spins a silken sheet, figure 148 C, across the front of the case. This sheet is perforated in the center by a number of small holes arranged in a circle. Surrounding the perforations there is an area which is free from

perforations. At the caudal end of the pupa (about two-thirds the length of the case from its cephalic end) a second sheet of silk, figure 148 B, crosses the case. This second sheet resembles the first, except that the circular area of perforations is larger. Pupation takes place on the exposed areas on sticks or stones where the larval life was spent.

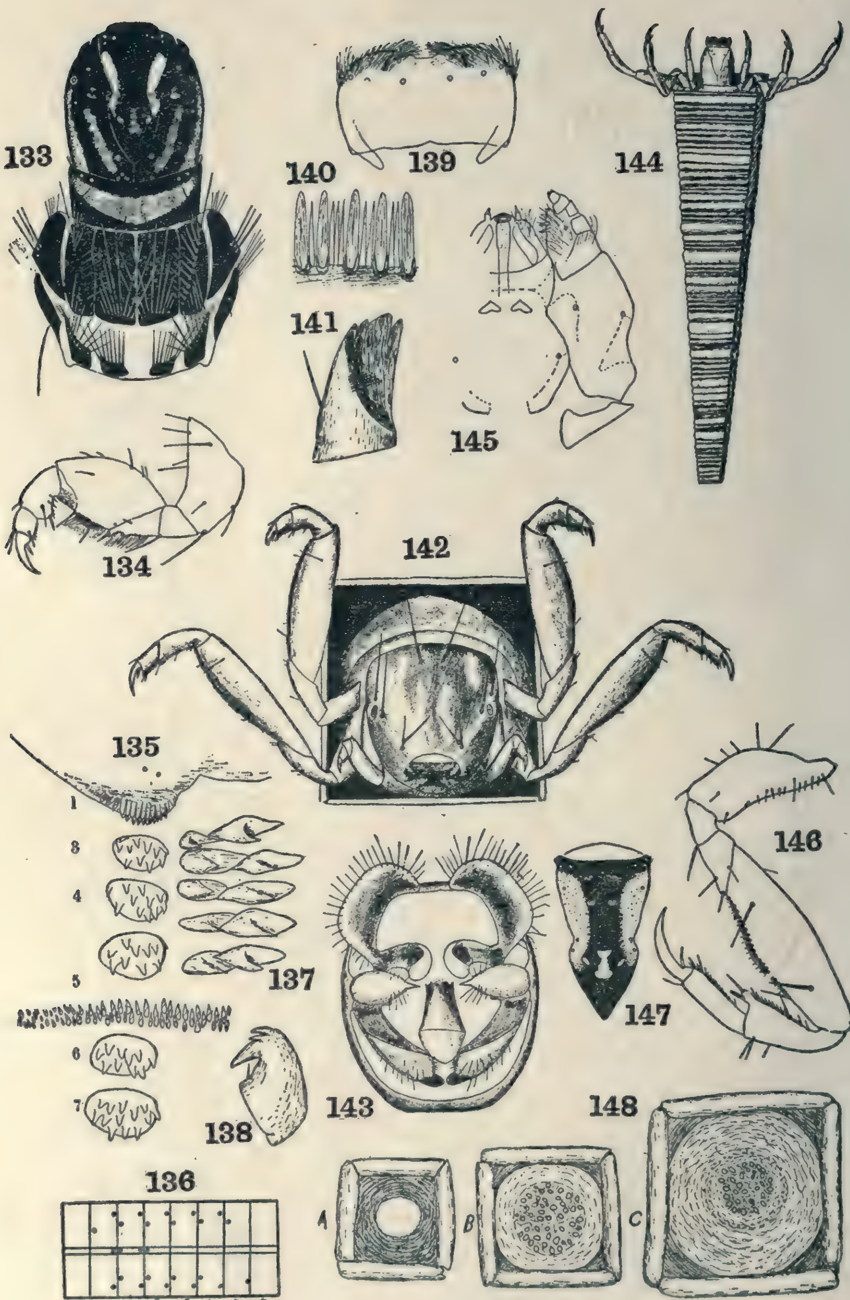
Period of Emerging.—Specimens confined in cages in their natural habitat emerged during the latter part of May and first part of June.

Food of the Larvæ.—According to Miss Helen Murphy, who followed the species from the egg to the adult, "the cases are completed in about five hours. The larvæ then start to eat. For the first two weeks the food consists entirely of diatoms, such as Meridion, Cymbella, Navicula, Cocconema, Fragilaria, and Synedra. This food they obtain by browsing on the stones and vegetation, over which they hastily scramble. At the end of the third week the green algæ Oedogonium, Cladophora, Ulothrix, Cylindrospermum, and bits of seed plants are added to the diet."

"At the end of the sixth week the larva is about three-sixteenths of an inch in length." "From a purely herbivorous diet, obtained by active searching, they now become mainly carnivorous, waiting in a most receptive attitude for whatever may come within their powerful grasp." "An examination of their stomachs at this time reveals quantities of fragments of mayflies, Hydrachnids, Chironomids, and Crustacea, as well as Chlorophyceæ and diatoms of several genera. This miscellaneous assortment of animal and vegetable foods from the stomachs, as well as observations on the habits of the larvæ, leads us to believe that they will eat any organic matter that floats within their grasp. The combs of fine spines on the legs (figures 134, 140, and 146) seem to serve as plancton sieves, and the long, hooked armature of the tarsus certainly is adapted to a carnivorous diet."

Description of the Larva.—The length of the mature larva, figure 133, is about 12 mm.; its breadth is about 2.5 mm. In life the soft parts are green; the heavily chitinized parts are dark-brown, appearing black when viewed in reflected light. The abdomen tapers gradually from the first to the last segment.

*The Head.*—The head is black, marked with brown on the




(See Page 85 for Description of Cut.)

dorsum, figure 133; the sides are black, with a brown mark extending back from the caudal margin of the eye to the caudal margin of the head as shown in the figure; the venter is black, except the ventral mouth-parts, which are brown; the labrum is black, with setæ arranged as in figure 139; its cephalic pair of setæ are saber-like and are directed toward the median line, their tips almost meeting; the other setæ are normal; the front margin is clothed with a dense fringe of hairs; the frons has the markings and distribution of setæ, shown in figure 147.

*The Thorax.*—The thorax is marked on the dorsum, as in figure 133; the prothorax has a depressed crescentic mark of brown across the dorsum and extending down the sides; the mesothorax is armed dorsally with four narrowly separated chitinous plates, which are without markings, but are armed with long setæ, figure 133; on each side of the body there is a somewhat triangular plate; the metathorax is armed above with four smaller dorsal plates and a single plate on each side of the body, figure 133; on the sides the chitin of the dorsum of the prothorax extends to the base of the front legs; on the outside of each mesothoracic coxa there is a triangular piece of heavy chitin which bears a tuft of long, black setæ on its front and on its ventral corners; the metathorax bears similar chitinous pieces, each of which has a single line of long, black setæ around its cephalic corner and a line of similar setæ, extending from a point on its cephalic margin well above its ventral corner to a point on its venter considerably below the limits of the chitinous triangle; the venter of the thoracic segments is without heavy chitin. The legs, figures 134 and 146, are

BRACHYCENTRUS NIGRISOMA.

133. Larva. Head and thorax.
134. Larva. Front leg.
135. Pupa. Chitinous plates of left side of abdomen.
136. Larva. Distribution of giills.
137. Pupa. Detail of group of hooks, 2nd series, segment 5.
138. Larva. Drag-hook.
139. Larva. Labrum.
140. Larva. Part of comb of 2nd leg.
141. Larva. Mandible.
142. Larva in case. Natural position, cephalic view.
143. Adult. Male genitalia, caudal view.
144. Larva in case. Dorsal view.
145. Larva. Lower mouthparts.
146. Larva. Middle leg.
147. Larva. Frons.
148. Pupal case. a) caudal end of case. b) caudal sieve. c) cephalic sieve.

all armed with powerful curved claws; the form and distribution of setæ is shown in the accompanying figures; the apical membranous part of the front femur adjoining the tibia is somewhat soft and is overspread with minute conic teeth; the inner edge of the trochanter and femur of the front leg is armed with a single row of long straw-colored hairs, and the femur is armed also with a row of short spines on its inner edge; the second and third pairs of legs are much alike; the inner edge of the femur is armed with a line of sharply-pointed spines of two kinds—one kind, apparently very rigid, is dark in color and arises from well-defined sockets; these spines are separated by one, two, or three spines of lighter color and apparently less rigidity, which do not arise from sockets; the spines in detail are shown in figure 140.

Figure 136 illustrates diagrammatically the arrangement of gills on the left side of the abdomen.

Description of the Pupa.—Length, 10—13 mm.; breadth, 3—3.5 mm.

The mandibles are strongly chitinized. The antennæ reach to the tip of the abdomen. The dorsal plates of the abdomen and armature of the dorsal surface of the first segment are shown in figure 135; the hooks of the second series on the fifth segment are not borne on a single plate, but occur as independent chitinous pieces, forming a line across the dorsum of the segment. Figure 137 shows the hooks in detail. A few minute setæ occur on each segment—these are slightly longer and more numerous on the last segment; the lower sides of segments 1 to 7 bear narrow obliquely downward-pointing lines of dark color; the last segment is shaped like an obtuse arrowhead. When viewed from above its two curved processes are equal to a little more than half its length. The lateral fringe is better developed than that of the larva; it begins behind the middle of the fifth segment and ends on the ventral side of segment eight.

The Case, figure 144, is 15—18 mm. wide at its anterior end and about 1.5 mm. wide at its posterior end; it is constructed of minute twigs, root fibers, and fragments of wood cut to the proper length to give even and straight edges, gradually diverging toward the anterior end. In cross-section the outer surface of the case is square; the interior is lined with a cylindrical tube of tough silk, which is equal in diameter to the inside diameter of the square

exterior framework; the spaces between the corners of the square exterior and the silken tube are filled with silk. At the caudal end of the case, figure 148 A, the tube narrows abruptly, leaving a circular opening about one-half mm. in diameter. So toughly made are these cases that they persist without deterioration from season to season after their occupants have left them.

## FAMILY CALAMOCERATIDÆ.

This small family is represented in North America by but eight described species. Other members of the family, except two species in Europe, occur in remote countries where little or nothing has been done with the immature stages.

For this reason it is impossible to assemble a group of family characters with any degree of certainty that they will include all of the species of the family when these become known.

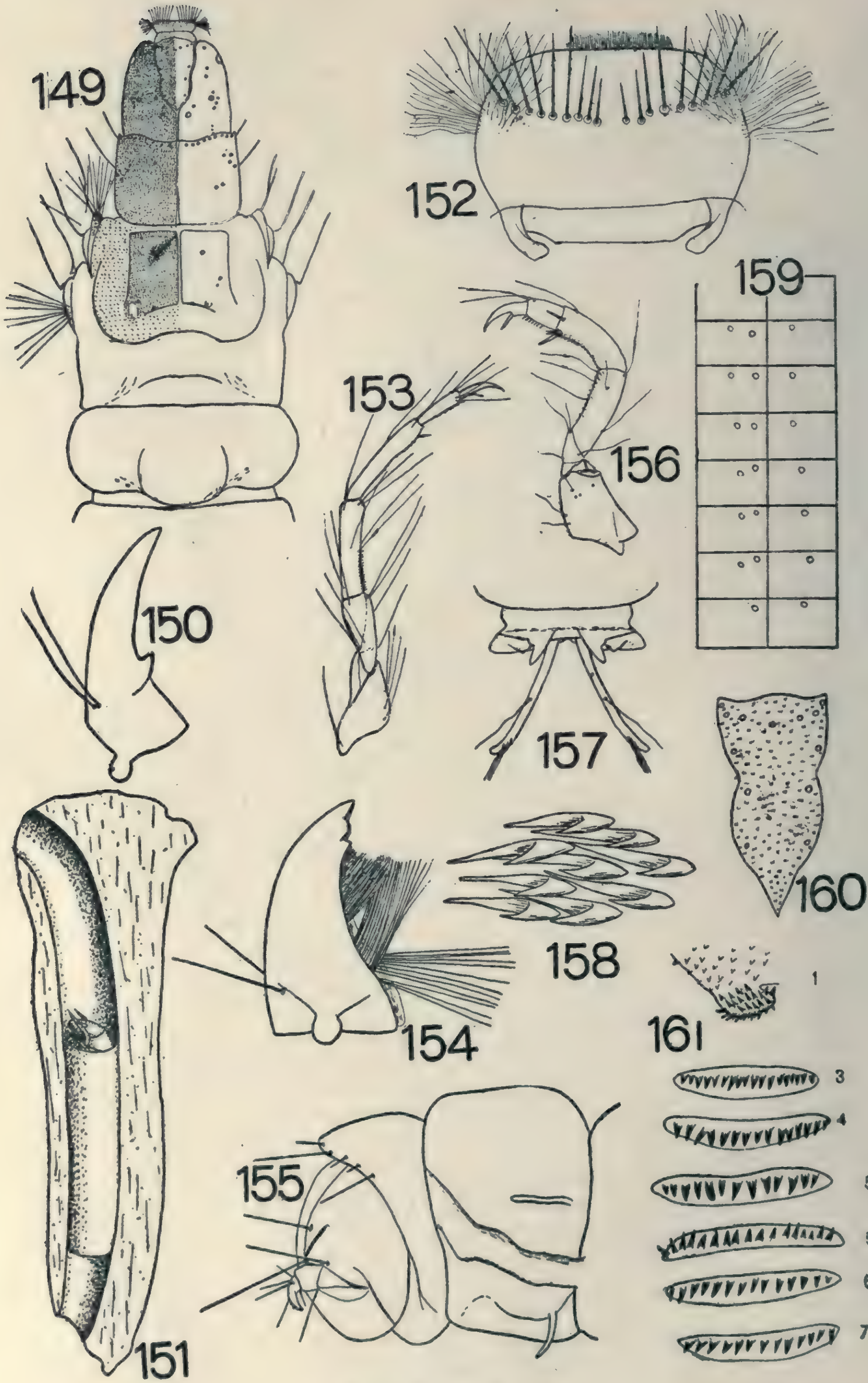
*Ganonema americanum,* the only known American larva, is described below.

### Ganonema Americanum.

Habitat.—The larvæ are abundant in the alder-bordered streams of Michigan Hollow and McLean Swamp.

Habits.—The larvæ are active during the summer, fall, and winter. In February, with the thermometer below 20° Fahr., they were apparently as active as during the heat of summer. By the end of April they had left the middle of the stream and had firmly attached the anterior ends of their cases to solid supports near the stream's margin. At this time flat stones were fastened over both ends of their cases—a frequent practice of the larvæ at all seasons during periods of rest.

The wood-boring habits of this species may, when we are familiar with more species, prove a not uncommon method of case-making. I have found identical cases in streams on the Western slope of the central range of the Colombian Andes, and also in the Valley of the Magdalena River, east of this range. Similar habits are described and figured by G. V. Hudson, in "New Zealand Neuroptera," 1904, for *Triplectides obsoleta (Pseudonema obsoleta)* of the family Leptoceridæ. Hudson, however, states that *T. obsoleta* under natural conditions sometimes constructs cases of fragments of leaves.




(*See Page 89 for Description of Cut.*)

*Food.*—The food of the larvæ, as demonstrated by examinations of the contents of many stomachs at different seasons, consists of fine powder rasped from submerged wood.

PERIOD OF EMERGING.—The specimens in captivity emerged from June 4 to July 11.

DESCRIPTION OF THE LARVA.—Length, 18—20 mm.; width, 3 mm. Color of chitinous portions of head and thorax, black when viewed with reflected light; when viewed with transmitted light, mounted specimens show faintly lighter markings. The legs are black, ringed with white. Fleshy portions of prothorax and abdomen are pale-brownish white. The anal hooks are brown.

*The Head.*—The head is narrowest at its anterior end and broadens very gradually to near its base, where it narrows. Behind the place of its greatest diameter it is inclosed within the first thoracic segment. The distribution of setæ on the dorsal surface is shown in figure 149. The frons, figure 160, has a semi-circular line of setæ, curving away from the cephalic margin and three other more widely-separated setæ near each side. Like the heavily chitinized portions of the head and thorax, the frons is thickly marked by minute transverse lines, from each of which arise several very minute hairs, giving, except under high power, a somewhat scale-like appearance. The mandibles, figure 154, are deeply grooved along their inner margin to the very tip of the apical tooth. Besides the apical tooth, two lateral teeth are present on each edge of the groove. From the groove arise three well-defined brushes of hair. The inner brush is directed inward and backward; the middle and cephalic brushes are directed inward and toward the front; the cephalic brush is the most dense and is composed of extremely fine hairs. The labrum, figure 152, is crossed by a row

GANONEMA AMERICANUS.

149. Larva. Head and thorax.
150. Pupa. Mandible.
151. Case, longitudinal section.
152. Larva. Labrum.
153. Larva. Hind leg.
154. Larva. Mandible.
155. Larva. Terminal abdominal segments. Lateral view.
156. Larva. Front leg.
157. Pupa. Anal appendages, dorsal view.
158. Larva. Detail of hooklets covering lateral humps.
159. Larva. Distribution of gills.
160. Larva. Frons.
161. Pupa. Chitinous plates of left side of abdomen.

of 18 to 20 strong setæ whose bases almost touch, except on the median line, where there is a greater space. On each latero-anterior angle there is a patch of long, fine hairs, and in the middle of the cephalic margin a dense line of short hairs.

*The Thorax.*—Prothorax heavily chitinized above and on the sides. The area between and in back of the coxal cavities is membranous, except two narrow spots immediately in front of the mesothorax. Mesothorax with a chitinous area which extends back over the metathorax as far as the caudal margin of the hind coxæ. Within this area there is a well-defined, square bearing eight setæ, figure 149. The sides are not chitinous, except for a small black triangle behind each coxa, which bears a circle of about twelve setæ; the venter is free from heavy chitin, except for two narrow yellow spots on the caudal margin. The metathorax is without heavy chitin above. On the sides the distribution of chitinous plates is the same as on the mesothorax; the upper mark, however, is not so dark in color as on the preceding segment and bears more setæ, which are less nearly circular in arrangement. The venter differs from that of the mesothorax, only in having the chitinous areas near the caudal margins darker in color. The front leg, figure 156, is little more than half the length of the succeeding legs, but is more robust. It bears three stout spurs on the inner angle, next to the tarsus, and one isolated spur on the distal margin. On the inner margin of the basal segment of the tarsus there is a single row of short stout spines. The inner surface of the tibia bears numerous very short spines. The inner surface of the femur is sparsely armed with short triangular teeth. The coxa, on its inner margin, has a few short spines and over its entire surface has rows of fine, short hairs like those described for the frons. The two succeeding legs (figure 153 shows the hind leg), differ from the front leg in being longer and less robust, and in having fewer and weaker short spines. Each of these legs has but one tibial spur.

The abdomen is cylindrical and almost uniform in circumference throughout its length. The humps on the first segment are not greatly developed. The lateral humps bear an area of short, curved spines, whose points are directed forward. The gills are distributed on segments 2 to 8, above and below the lateral line, as diagrammed in figure 159. The lateral fringe, near the caudal

margin of the seventh abdominal segment, ends at the beginning of a fleshy raised line, figure 155, which crosses the suture between the seventh and eighth segments and, inclining upward, extends to the caudal margin of the eighth segment. Each side of this fleshy line is armed with curved, bifurcate spines directed backward. The anal hooks and the arrangement of setæ on the last abdominal segments are shown in figure 155.

Description of the Pupa.—Length, 13 mm.; mandible, figure 150. Tarsi flattened and fringed on each side by a row of black swimming hairs. Lateral fringe black. A narrow black line parallels the lateral fringe beneath, extending to the caudal margin of the eighth segment, where the two converge. A narrow black line above the lateral line contains the spiracles. Abdominal segments 2 to 9 have tufts of hair near their caudal margins above. On the caudal margin of the first abdominal segment there is a pair of lobes, figure 161, covered with sharp spines. Above these lobes are sparse backward-pointing teeth. The chitinous plates of the abdomen are shown in figure 161. The posterior end of the pupa is represented in figure 157.

The Case.—The cases made by this species differ greatly from those of other described American Trichopterous larvæ. Instead of the usual dwellings of stones or twigs, or tubes of silk, these utilize fallen twigs of wood from the stream-bottom. The twigs are hollowed from end to end, and lined with silk, forming portable cases, which are a natural part of their surroundings. These larvæ abound among the litter of branches and twigs from the surrounding forest. In spite of their abundance they are most inconspicuous among the débris. They crawl with a jerky motion, as if swayed by the passing current, or rest, as if lodged, on a submerged branch, and when disturbed, let go, drifting down stream with the current.

The twigs used in cases vary greatly in length and diameter, apparently being selected at random from the litter on the bottom of the forest stream. Sometimes pieces of heavy bark or fragments of broken wood are used. A cylindrical hole always penetrates the wood from end to end. In some twigs the chamber forks near the anterior end, one outlet curving downward and opening to the exterior at one side, while the other perforates the end of the stick. The side outlet, when present, forms the anterior

entrance to the case, the other in the end being plugged with silt or with small pebbles. Sometimes the chamber curves downward without forking, as in figure 151. The chamber is always lined with silk. (Figure 151 represents a case with the silk tube cut away, except around the larva.) Although there is considerable variation in the size of the twigs used, their average size increases with the growth of the larvæ. To ascertain how the change in cases is made, several experiments were made with captive larvæ. Some were removed from their cases and put in cages with twigs of appropriate size. These larvæ did not attempt to use the wood for making new cases, but merely spun silken tubes to which particles of silt adhered; others, which had one side removed from their cases, repaired the damage with silk and silt. One larva repaired the damaged side with silk and fragments of bark and then proceeded to cut away the two ends of its case. It worked from the damaged side of the case, cutting narrow incisions across the twig until the opposite side was reached. The operation of cutting the two incisions across the twig ten millimeters in diameter consumed about twenty-four hours. Two specimens, which were retained in aquaria in the laboratory, attached the anterior ends of their cases securely, by means of silk, to the ends of solid twigs, and then drilled into the wood, emitting, during the task, an abundance of very finely-powdered wood. One of these new dwellings proved too long for its occupant. It was accordingly girdled with a circular incision, which was deepened until one end of the twig was completely cut away. Several sticks similarly ringed were found in the creek where the larvæ occur. No doubt this is the usual method of changing cases, as larval growth proceeds.

## FAMILY ODONTOCERIDÆ.

This small family is represented in the American fauna by but a single species with known immature stage.

Distinctive Characters.—The labrum is distinctly longer than broad. The pronotum and mesonotum are chitinized; the metanotum has four chitinous plates, the two median of which are much broader than long, crossing the median line.

*The Head.*—The head is depressed in form. The labrum is longer than broad, with two pairs of cycle-shaped, pale setæ on

the front margin. The pleuræ are contiguous behind the small, triangular gula.

*The Thorax.*—The pronotum is extended in a thorn-like point at each cephalic corner.

The mesonotum is completely chitinized.

The metathorax bears two broad chitinous plates transversely across the dorsal surface, and a single plate on each side.

## Psilotreta Frontalis.

Habitat.—Psilotreta larvæ inhabit almost all of the larger streams of the uplands, but are never found near Cayuga Lake's level. They are especially abundant in Mud Creek, near Freeville.

In the upland streams the larvæ are confined to the riffles, and the portions of the streams with stony bottoms.

Habits.—During their early life the larvæ are free moving, crawling over the stream's bottom. At this time they show no evidence of social instinct, coming together only by chance in their wanderings.

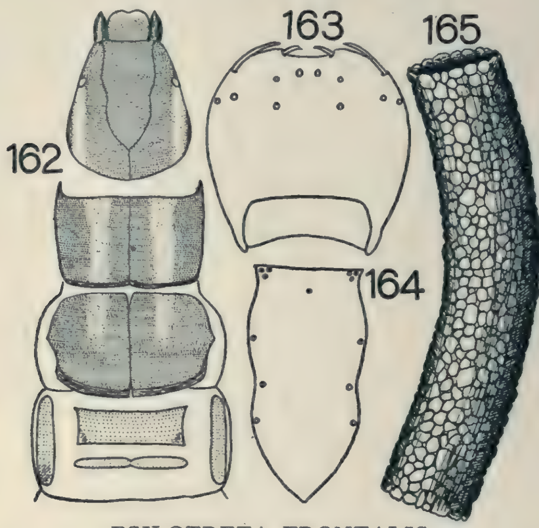
In the early spring, just before pupation, the larvæ develop a remarkable gregarious habit. Almost all of the larvæ within certain areas of the stream congregate on the sides of a few selected stones in such numbers that their cases are sometimes piled one on top of another to a depth of an inch or more, while other stones of the region are entirely uninhabited. The cases are always placed parallel to each other, with their cephalic ends directed toward the surface of the water. Such congregations of cases may often be removed entire from the supporting stone, when the mass has much the form of a cord of neatly cut wood.

Period of Emerging.—Adults emerge during the latter week of May and the first week of June.

Description of Larva.—Color in life deep blue-green.

*Head.*—On the dorsal surface the head is flattened. In color it is deep mahogany-brown, with a light line commencing at each eye and extending back to the caudal margin, and a narrow light cephalic border to the labrum, figure 162. On the ventral surface the head has a light-brown median mark, which shades into deep mahogany-brown toward the lateral margins.

*The Thorax.*—The chitinous shield of the pronotum is extended forward in thorn-like form at each cephalic corner. In color the pronotum is deep mahogany-brown, with a broad, lighter-brown line on each side of the median suture.




PSILOTRETA FRONTALIS.

162. Larva. Head and thorax. 164. Larva. Frons.
163. Larva. Labrum. 165. Case.

The shield of the mesonotum is deep mahogany-brown, with a lighter line on each side of the median suture, which, in some specimens, ends at about the middle of the sclerite, and in other specimens extends back to the caudal margin of the shield.

The metanotum, figure 162, bears a broad, brown, transverse plate near the cephalic margin, behind which there is a pale, narrow, transverse plate; on each side of the segment there is an elongate brown plate.

*The Abdomen.*—On the first segment all three spacing-humps are represented by obtuse mounds. The gills of the subdorsal and subventral series are well developed, occurring in tufts of from five to twenty-five filaments behind the cephalic margin of the segment. The lateral series of gills is represented by a few weak filaments on the first three or four gill-bearing segments, or is entirely wanting. The drag-hooks are stout, with heavily chitinized supports on the prolegs.

Description of the Case.—The case of the mature larva, figure 165, has the form of a slightly-curved cylinder of sand grains. Immature larvæ cases differ only in being tapered toward the caudal end.

The case of the pupa has a flat pebble set neatly within the aperture at each end of the tube. All spaces around these stones are tightly closed with heavy silk, leaving no respiratory apertures. The habit of enclosing the pupa tightly, without provision for respiratory currents, is unusual among case-building Trichopterous larvæ, but is always practiced by the cocoon-making family, Rhyacophilidæ.

## FAMILY LEPTOCERIDÆ.

Habitat.—The known Leptocerid larvæ of the American fauna are inhabitants of standing waters—lakes, ponds, and the dilatations of streams—except *Leptocerus ancylus,* which is found on stones in the riffles of streams, as well as on the stones of wave-beaten lake shores.

Though the most abundant of our Trichoptera belong to this family, the early stages of but few have been described, and the habits of these few are but imperfectly known. At times, during the early days of July, the black iron bridge across the northern end of Cayuga Lake appears as white as snow, with millions of adult insects of this family, mostly the beautiful snowy species of the genus Leptocella. At such times a passing train sends a cloud of countless numbers of the insects into the air, after a few minutes' flight to settle again as a white covering upon the bridge.

Habits.—The habits of so few species of our fauna are known that it does not seem advisable to generalize on the activities of the entire family. Those that are known will be described under the various species.

Description of the Larvæ.—*Distinctive characters.* A suture beginning in the region of the eye dips downward and extends back to the hind margin of the head. The femur of the hind legs, and in most species of the middle legs, is divided into two segments.

*The Head.*—The head is oval, with long antennæ arising close behind the mandibles. The labrum is much broader than long,

and never possesses a row of twenty or more heavy bristles. The gula is subquadrate, widely separating the epicrania.

*The Thorax.*—The pronotum is chitinous. On each side of the prothorax a chitinous plate, differing somewhat in form in different species, extends forward above the base of each coxa.

The mesonotum is chitinized.

The metanotum lacks chitinous plates.

The legs will offer unusual taxonomic opportunities when they are more thoroughly studied and the homology of the segments is better known.

The forelegs are short, broad, and flat, with varying armature in different species.

The middle and hind legs are slender and show great difference in armature, and in the relative length of the segments. In the hind legs of all known species, and in the middle legs of all except Setodes, there is a short segment at the base of the femur, which has led Ulmer to state that the femur is divided. It is not clear, however, that this segment does not belong to the trochanter instead of to the femur. Besides this suture, cutting off a sclerite of doubtful homology, there is, as is usual in Trichopterous larvæ, a suture near the base of the trochanter. In the Leptoceridæ this suture separates a short basal piece from a much longer distal piece.

*The Abdomen.*—On the first segment all three spacing-humps are well developed. The lateral fringe is short and fine and extends from the third to the seventh segment. The basal segments of the prolegs are fused to form an apparent tenth segment. The claws are small.

In this family it is impossible to identify the species by fragments of the cast larval skin retained in the case after pupation. The exuvia is eliminated through the caudal opening of the pupal case as soon as transformation from the larva takes place.

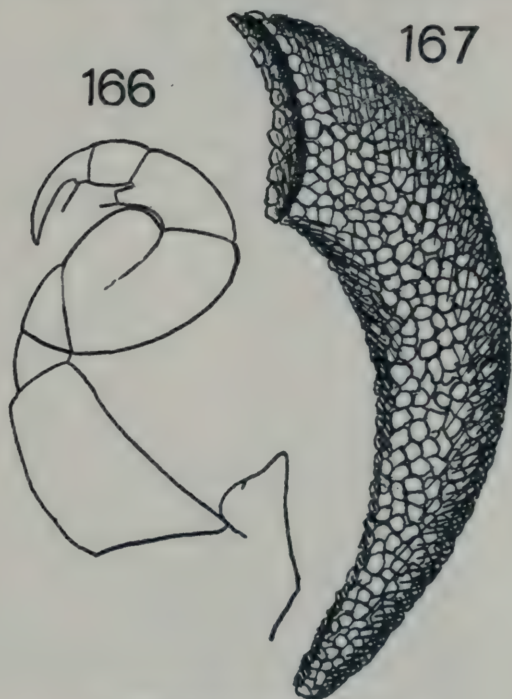
## Leptocerus Ancylus.

The larvæ are common in all streams of the region, except those of the highest altitudes; and they also occur on stones of the wave-beaten shores of Cayuga Lake.

Vorhies, who first described the larvæ and adults, determined

the Ithaca specimens as identical with his material from Wisconsin, in spite of the decided difference in form of the larvæ's cases.

The color and soft parts of our specimens deteriorated in the preservative fluid, but the structure of the chitinous parts is well preserved. The fore leg of the larva is shown in figure 166.




LEPTOCERUS ANCYLUS.

166. Larva. Front leg. 167. Case.

In the Ithaca region the larvæ make cases of sand grains in the form of curvèd cornucopias, figure 167, without lateral flanges, and without decided hood-like covers on the cephalic ends. In cross-section the cases are cylindrical.

The cases of the material from Wisconsin have decided lateral flanges, and have well-developed hoods that completely cover the larvæ's heads.

## Mystacides Sepulchralis.

Habitat.—The larvæ are common insects in Beebe Lake, Dwyer's Pond, and in many of the slow, deep pools of Cascadilla and Fall Creeks.

Habits.—The species lives among the accumulation of sticks and rubbish on the pool's bottom.

The prepupal state has its beginning from the middle of May till the first part of June. At this time the cases are attached to the exposed surfaces of submerged sticks.

Food.—Stomachs of preserved specimens contained a thoroughly masticated pulp, apparently of vegetable origin.

Period of Emerging.—Specimens in captivity emerged from the middle of June until the first part of July. Probably under natural conditions their period of emerging is of considerably longer duration.

Distinctive Characters of Larva.—Length, 9 mm. Without swimming hairs on second and third pairs of legs.

*Head*.—The extent of the dark coloring varies greatly in different individuals. In dark specimens, figure 168, the cephalic part of the frons is smoky-brown; behind the brown area the head is pale yellow, except for several sharply-defined spots behind the frons; a dark mark begins behind each antenna and extends back to the hind margin of the head; the sides of the head are pale yellow with numerous dark-brown spots; on the under surface the head is dark-brown without markings.

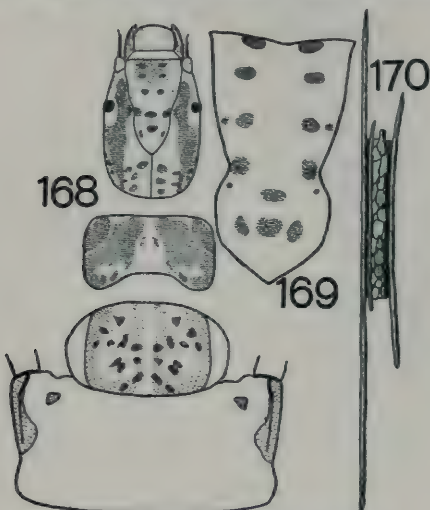
Pale specimens have a ground color of light straw yellow, marked by numerous brown spots. No other markings are present.

*The Thorax*.—The prothorax, like the head, is subject to great variation in coloration. Dark specimens, figure 168, have the ground color of the prothorax almost entirely dark-brown, almost obliterating the mottling; in such specimens a narrow, light-colored line encircles each "shoulder." In light-colored specimens the ground color is pale, thickly mottled with dark-brown spots. All intermediate gradations of coloration occur.

The mesothorax of dark specimens is smoky, mottled with dark-brown, figure 168. In light specimens the smoky ground color is lacking.

The metathorax has a small chitinous plate bearing a few setæ on each "shoulder."

The fore leg is broad and flat. The middle leg bears a tarsal claw that is as long as the basal tarsal joint. The distal segment




MYSTACIDES SEPULCHRALIS.
168. Larva. Head and thorax. 170. Case.
169. Larva. Frons.

of the trochanter is more than twice as long as the basal segment. The femur is divided into a long apical and very short basal piece. The hind leg bears a tarsal claw about half as long as the basal joint. The tibia has a swelling at about the middle of the segment that gives the segment the appearance of being divided, though carefully-prepared mounts have revealed no suture. The femur is divided into a short basal and long apical piece. The basal piece of the trochanter is short and the apical piece very long.

*The Abdomen.*—The first abdominal segment has a prominent bulb-shaped dorsal spacing-hump; the lateral humps are smaller; on the caudal side of each lateral hump there is a brown chitinous plate with a black dorsal margin. Abdominal gills are absent. The lateral fringe consists of weak, pale hairs. The drag-hooks are stout; chitinous supports at their bases are almost entirely wanting.

Description of Case.—The case of the larva, figure 170, consists of a slightly-tapering tube of sand grains, or minute bark

fragments, lined with silk. In length the tube is about 12 mm., and in breadth about 1.5 mm. On opposite sides are fastened pine needles, or grass stems, or slender sticks, paralleling the tube and extending well beyond its caudal and cephalic ends.

Before pupation a sheet of silk with a slender, minute, round perforation in the center is spun across each end.

## TRIÆNODES SP.

HABITAT.—The larvæ are common in the Cove, Michigan Pond, and many ponds and dilatations of creeks that contain Potamogetons and other aquatic plants.

HABITS.—The larvæ dwell among the branches of submerged plants, seldom descending to the pond's bottom. Unlike other species that dwell in similar places, but must crawl from plant to plant, the larvæ of Triænodes swim rapidly from place to place through the open water.

Before pupation the cases are attached to the stems of plants or rolled in submerged leaves.

PERIOD OF EMERGING.—Adults emerge about the middle of June.

DISTINCTIVE CHARACTERS OF LARVA.—Length, 10 mm. Long swimming hairs on third pair of legs.

*Head.*—The ground color is straw yellow, figure 171; a dark mark on each side of the frons begins at the outer corner of the labrum and extends back to the hind margin of the head, with a narrow break behind the antenna; on the ventral surface a smoky area begins at the base of each mandible and extends back to the hind margin of the head. The gula is pale. The frons, figure 172, is without pattern. The mandibles are brown.

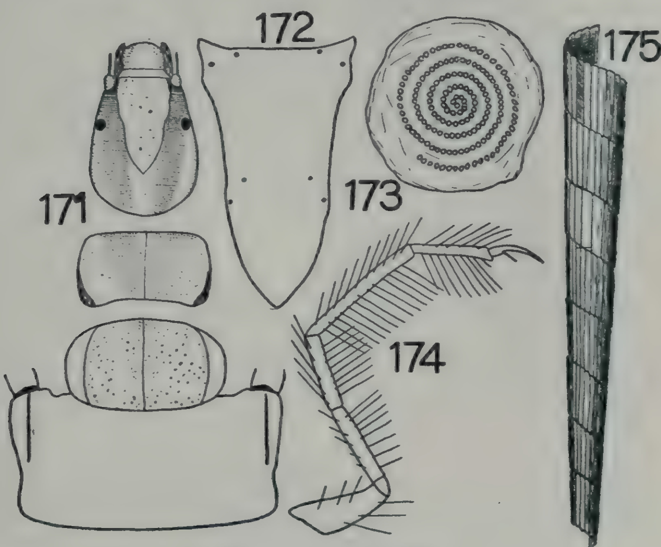
*Thorax.*—The prothorax is smoky on the dorsal surface, shading to straw yellow on the sides. The chitinous supports at the base of the legs are dark-brown and black. A thorn-like process projects forward above the base of each coxa.

On the mesothorax the scutellum is of a pale, smoky color, with indistinct dark spots. The pleural suture is long and narrow, and deep black in color.

The metathorax bears no dorsal chitinous plates. The pleural

suture is very long, extending diagonally up and back three-fourths the distance to the caudal margin of the segment.

The front leg is short and stout. The tibia is broadened on its inner distal angle and bears a single spur. Projecting forward, above the base of the leg, there is a flat chitinous projection which differs but slightly from that of Setodes, figure 178.




TRIAENODES SP.

171. Larva. Head and thorax.
172. Larva. Frons.
173. Egg mass.
174. Larva. Middle leg.
175. Case.

The middle leg is longer and less stout. The femur is divided into a long apical and very short basal piece. The trochanter has the apical piece more than twice as long as the basal piece.

The hind leg is long and slender, and is provided with numerous long swimming hairs. The distal piece of the trochanter is much longer than the basal piece, appearing as a distinct joint.

*The Abdomen.*—On the first segment the spacing humps are large and bulb-like; the lateral humps have no chitinous plates, but have a thick fringe of microscopic forward-pointing hairs. The lateral fringe is present, but is very weak. Large gills arising singly occur on segments 2 to 8, inclusive. Except for the drag-hooks the prolegs are not chitinized.

Description of Eggs.—During the latter half of June egg masses may be found on the under surface of floating leaves and sticks. The gelatinous mass is disc-shaped, measuring about 5 mm. in diameter. Inside the gelatin the eggs are arranged in a spiral of about 200 eggs, figure 173.

The egg masses occur in very great numbers, often completely covering the under sides of submerged leaves, or even placed one on top of another.

Description of Case.—In form the case is an elongate cornucopia, usually measuring 1.5 cm.—2.5 cm. It is made of thread-like sections of the epidermis of leaves, or the fine ribs of leaves, wound in a spiral. The leaf sections are cut and fitted end to end and side to side with wonderful skill and precision.

By the time newly-hatched larvæ have left the gelatinous egg mass, they have constructed irregular, web-like cases of transparent silk. To this silk case silt adheres. After two or three days from the time of hatching the silk case is replaced by the characteristic spiral case of the species.

## Setodes Grandis.

Habitat.—In the beds of *Potamogeton americanus* in Spencer Lake the species occurs in great abundance. At an earlier date Professor Comstock found the larvæ abundantly among the aquatic vegetation at the north end of Cayuga Lake. During recent years, however, it has been impossible to find a single specimen in this situation.

Habits.—In Spencer Lake the larvæ feed on *Potamogeton americanus*. On this plant they, with their brilliant green color showing through their transparent cases, can hardly be distinguished from the stipules of the leaves of their food plant, which they resemble exactly in size and form.

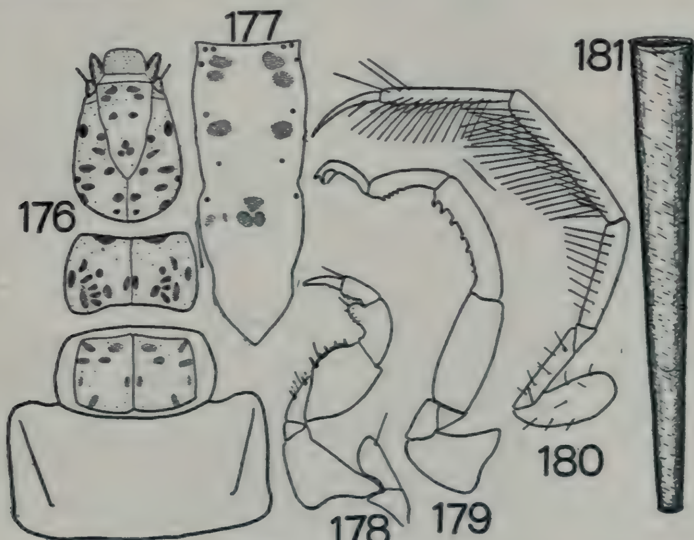
Vorhies experienced great difficulty in distinguishing the larvæ from the spine-like leaves of *Ceratophyllum,* on which he found them common in Wisconsin.

Before pupation one side of the cephalic end of the case is made fast to the host plant, leaving the case projecting in a decidedly spine-like manner. The pupa, like the larva, is brilliant green and shows its color distinctly through the transparent case.

The peculiar curved form of the tibia and basal tarsal joint of the middle leg indicates some peculiar habit in the larval life of this species.

PERIOD OF EMERGING.—Our earliest record of emerging is June 20th. At that time most specimens had pupated, but a few were still in the prepupal state. These late specimens would probably emerge about the middle of July.

DISTINCTIVE CHARACTERS OF LARVA.—Color light-green in life. Length, 9 mm. Tarsus of middle leg curved, figure 179. Swimming hairs on hind legs.




SETODES GRANDIS.

176. Larva. Head and thorax.
177. Larva. Frons.
178. Front leg.
179. Middle leg.
180. Larva. Hind leg.
181. Case.

*Head.*—The ground color of the head is pale straw yellow; on the dorsal surface it is spotted with dark-brown, as in figure 176; the ventral surface is without marks. The mandibles are deeply grooved, and have several teeth on the inner surface; in color they are brown.

*The Thorax.*—The prothorax is straw yellow, mottled with oval brown spots, as in figure 176.

On the mesothorax the dorsal plates are straw yellow, with a few dark oval spots.

The metathorax is without chitinous plates.

The legs are illustrated in figures 178, 179, and 180. On the middle leg the tarsal claw is forked near its tip; the basal joint is slightly curved and is armed with about five thorns on its inner surface. The tibia is slightly curved and is armed with several prominent thorns on its inner surface. There is no indication of a suture in its femur.

The hind leg has numerous long swimming hairs. The short basal segment of the femur is well marked. The trochanter is divided into a short basal and long apical piece.

*The Abdomen.*—Gills are absent on this species, though they are present on the species of the genus in the European fauna.

Description of the Case.—The case has the form of an elongate cone. It is made of pale yellow transparent silk, through which the color and form of the bright green larva or pupa can be distinctly seen. Under a lens the separate strands of silk can be plainly seen, wound in spiral form like the leaf fragments in the case of Triænodes.

The case of the pupa, figure 181, has a convex disc of silk across its cephalic end. In the center of this disc there is a small circular opening. At the caudal end of the pupa's body, about one third from the caudal end of the case, there is a strongly convex partition of silk with a comparatively large circular opening in its center. Through this opening the caudal appendages of the pupa sometimes project, and through it the cast skin of the last larval molt is eliminated.

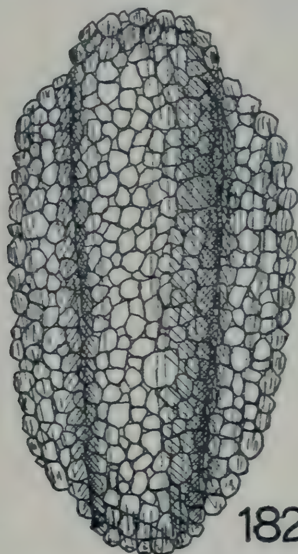
## FAMILY MOLANNIDÆ.

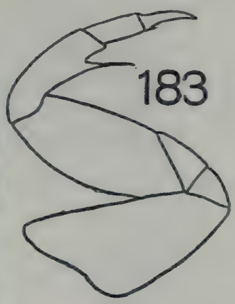
In the American fauna only the genus Molanna has known immature stages.

Description of the Larvæ.—The gula is subquadrate, widely separating the pleuræ. The pronotum and mesonotum are chitinized, the metanotum membranous. The prosternal horn is lacking. All three spacing-humps are present on the first abdominal segment.

## Genus Molanna.

Habitat.—Larvæ of the genus Molanna were found in the sand of a small stream in the McLean swamp. Unfortunately the


182


183

MOLANNA SP.

182. Case. 183. Larva. Front leg.

alcohol evaporated from the bottle of preserved specimens, leaving the larvæ worthless, but the cases did not deteriorate.

Adults of the genus are not uncommon near Cayuga Lake, from which they probably emerge.

Habits.—The larvæ observed were neatly nestled in the sand of the stream's bottom, where the wings of their cases blended so perfectly with the surrounding sand that they were most difficult to detect. Probably the genus would be found not uncommon if the cases could be more easily seen.

The Larvæ.—Molanna is the only American genus of the subfamily Molanninæ, which can readily be distinguished by the spur of the middle and front tibia. In Molanninæ the spur arises on a distinct prominence, while in the subfamily Beræinæ the prominence is entirely absent. Figure 183 represents the front leg of *Molanna uniophila,* furnished by Mr. Vorhies.

## FAMILY HYDROPSYCHIDÆ.

The family is divided into two subfamilies. The Macronematinæ are abundant in the Great Lake region, but have not been found in the vicinity of Ithaca. Their larvæ probably live in large lakes and slow-moving rivers. As yet there is no published account of their immature stages.

The subfamily Hydropsychinæ is represented in our fauna by a few species belonging to three genera. These have been carefully studied by Miss Alice Noyes and have been recorded by her in 1917, and in the manuscript of a forthcoming paper. The present account of the larvæ is condensed from the work of Miss Noyes.

HABITS.—The habits of our three genera of Hydropsychinæ differ one from another only in minor details. The best-known species are recorded in the genus Hydropsyche, but probably most authors have not made generic determinations within the family. Hydropsychid larvæ dwell only in swift-flowing waters and on the wave-beaten shores of lakes. In these situations they occur in vast numbers. Miss Noyes seems to have found it not uncommon to find as many as 165 larvæ on a square of the stream's bottom measuring only 8½ x 8½ inches. The larvæ are most abundant on the exposed surfaces of stones, ledges, and even on the brinks of falls. In these situations they build the characteristic nets that are so well known in the literature on entomology. The nets, typically, have a semicircular opening facing upstream. From this opening the net extends back in bag-like form. The front end is made of fine silk, strengthened by irregular coarse strands. Behind the fine-meshed front margin there is an area of coarser mesh that acts as a seine. It is made of tough strands running in two directions, forming a mesh of minute squares, through which the water passes while straining out its burden of plancton and small insects. The larva lives in a silken tube at one end of the seine. From this retreat it can freely enter the trap to feed upon its catch of aquatic organisms.

FOOD OF THE LARVÆ.—Young larvæ feed upon green and blue-green algæ. In later life they change their diet to include also diatoms and various vegetable plancton, as well as Ostracods and

the larvæ of aquatic insects, such as mayfly nymphs and the larvæ of Chironomids.

In eating the insects the larvæ do not chew their victims, but grasp them with their fore legs and thrust them bodily into their alimentary cavity.

Description of the Larvæ.—The head is small. On the inner margin of the left mandible there is a tuft of bristles. The labrum is entirely chitinized.

All three thoracic segments bear dorsal chitinous plates. The prosternal horn is lacking. Branched gills are present on the meso- and meta-thorax.

The abdomen bears branched external gills and retractile rectal gills. Spacing-humps and the lateral fringe are lacking. There is no chitinous shield on the dorsal surface of the ninth segment, but the ventral surfaces of the eighth and ninth segments bear chitinous plates. Each proleg is armed with a tuft of long bristles slightly above the claw.

## FAMILY PSYCHOMYIDÆ.

The family includes only four genera and about thirty-five species. Of these all are confined to Europe, except a half-dozen species belonging to two genera, which occur in North America. The life histories of none of the North American species have been published.

Description of the Larvæ.—Head, prothorax, and the last abdominal segment smaller than the rest of the body. Head compressed. Mandibles asymmetrical, the left with two teeth on the inner margin, and with a thick brush of hairs in the groove; the right mandibles lacks teeth on the inner margin, and lacks a brush in the groove. On the thorax the pronotum alone bears a chitinous plate. The prosternal horn is lacking.

The European species of the family make no portable cases, but live on stones in long, loosely-spun galleries of silk and sand grains. They are found mostly in swift water, but also inhabit ponds and lakes.

## FAMILY POLYCENTROPIDÆ.

HABITAT.—The larvæ are common insects in all swift streams of the region, and in many situations of standing and slow-moving water.

HABITS.—In the swift streams about Ithaca several genera live among the rocks, making nets of different form. The habits of these have been described by Miss Noyes, 1914.

Several species of the genus Phylocentropus live in still or slowly-flowing water with sandy or muck bottoms. These larvæ spin subterranean tubes of silk, which sometimes reach ten centimeters in length. Often the tubes have one or more branches, and always they contain a bulbous swelling near the middle in which the larva probably rests, and in which pupation takes place. In natural position the tubes are beneath the ground, except about half an inch which projects upward into the water.

In summer, when the water recedes, it is not uncommon to find the exposed muck margins of upland swamp streams broken by innumerable quantities of these Phylocentropus chimneys, projecting upward into the air.

The genus offers an interesting field for future study to ascertain how the larva lives and feeds within its tube; how it uses its long, needle-like labium in spinning, and what particular use is made of its peculiar mandibles, legs, and other characteristic structures.

FOOD OF THE LARVÆ.—The larvæ of the species that have been studied feed upon plancton organisms and small insects that become entrapped in the mesh of their tubes.

DESCRIPTION OF THE LARVÆ.—The frons extends back to the caudal margin of the head, completely separating the epicrania. The labrum is entirely chitinized. The pronotum is chitinized, the meso- and meta-nota are soft.* Spacing-humps, the prosternal horn, the lateral fringe, and external gills are absent. There is no chitinous shield on the dorsal surface of the last abdominal segment. The prolegs are long, and are not fused on the median line to form an apparent tenth segment.

*In an exotic subfamily all three thoracic segments are chitinized dorsally.

## FAMILY PHILOPOTAMIDÆ.

The larvæ are common in most swift streams of the region. Among the stones of the bottom, where the force of the current is broken, they spin delicate nets of fine silk. In form the nets resemble the finger of a glove, attached at the open end, which is directed upstream, and free at the closed end. In the closed end of the net there is a small slit, just large enough to allow the escape of the larva in case of danger. The nets are 25—40 mm. in length and 3—4 mm. in breadth. They often occur in great numbers, completely covering the stones with a thin flocculent mass of dirty silk.

Though these nets cannot stand the full flow of the unbroken current, it is necessary that they be situated where there is enough flow of water to keep them distended. On lifting a net-covered stone from the water the nets invariably collapse, appearing as a mass of diatomaceous ooze through which the larvæ rapidly wriggle backward.

While the nets of the Philopotamid larvæ serve as hiding-places, their principal function is to serve as sieves through which the flowing water is strained; the larvæ feeding on the microscopic organic particles that are entangled in the mesh.

Description of Larvæ.—In color the larvæ are orange or yellow. The head is compressed; the labrum is entirely membranous; the cephalic margin of the frons is asymmetrical; the mandibles are asymmetrical, without tufts or bristles. The prothorax is the only thoracic segment that is chitinized dorsally. The abdomen has but few long hairs; the prolegs have but two long and two short bristles, slightly above the drag-hooks; gills, spacing-humps and lateral fringe are lacking.

Description of the Case.—Until nearly time for pupation the larvæ build the silken nets previously described. Before pupation they cover themselves with a rather irregular dome of pebbles, between which respiratory aperatures are left.

A careful study of the habits of the larvæ was made by Miss Alice Noyes, 1914, followed by a more detailed study with descriptions of the immature stages, the results of which are as yet in manuscript. On the results of this work the present account of the family and key to the species are based.

KEY TO LARVÆ PHILOPOTAMIDÆ.

A. Anterior margin of femur without a spur terminated by a bristle, anterior margin of clypeus but slightly indented. Lateral lobes of labrum but slightly developed.—*Philopotamus distinctus* (?)

A.A. Anterior margin of femur with spur terminated by a bristle, anterior margin of clypeus deeply indented. Lateral lobes of labrum well developed. *Chimarrha.*

B. Larva orange. Anterior margin of clypeus with deeper and more angular incision.—*C. aterrima.*

B.B. Larva pale yellow. Anterior margin of clypeus with shallower and more curved incision.—*C. socia.*

## FAMILY RHYACOPHILIDÆ.

HABITAT.—Rhyacophilid larvæ are fitted for life only in flowing water. Representatives of the family may be found in all of our streams that flow over a stony bottom and that do not go entirely dry during any part of the year.

HABITS.—Members of the two subfamilies differ widely in their larval habits. Members of the subfamily Rhyacophilinæ build no cases until the prepupal stage is reached. They crawl actively under or between stones, obtaining a firm hold on their support with their well-developed drag-hooks and legs. They are active larvæ that easily crawl about without the protection of a case. When their activity is about to cease for pupation, they build a strong fence of stones about themselves and in its protection undergo pupation.

Members of the subfamily Glossosomatinæ build cases of sand grains or pebbles. With their cases they crawl slowly over the exposed surfaces of stones. They are sluggish larvæ that cannot exist without the protection of a case. Pupation takes place on the exposed surfaces of stones, within their cases of sand.

Before pupation members of both subfamilies spin a sheet of silk closely about themselves. This silken cocoon has a strong superficial resemblance to the puparia of the higher Diptera. The silk of the cocoon is rubber-like in appearance, and even under the microscope shows no texture whatever, and no openings for transpiration of water are apparent. If taken from water and

dropped into strong alcohol the cocoon collapses, giving additional evidence that it contains no openings.

FOOD.—The Rhyacophilinæ sometimes eat filamentous algæ, but show a preference for small larvæ. The larvæ are taken into the stomach entire, without any chewing or mutilation.

The food of the Glossosomatinæ is not known. Stomachs examined contained a structureless material that could not be identified.

EMERGENCE.—Some species emerge throughout the entire summer, while the transformation of others is restricted to a short period.

DESCRIPTION OF LARVÆ.—The abdomen consists of nine segments; the prolegs are not fused to form an apparent tenth segment. Spacing-humps, prosternal horn, and lateral fringe are absent; external gills are absent on all known American species, but occur on some European species; rectal gills are present on some, perhaps all, species, but are usually retracted and not easily seen; the abdomen is but little wider than the thorax.

### KEY TO THE LARVÆ OF RHYACOPHILIDÆ.

A. Drag-hooks plainly more than half as long as last abdominal segment. Without transportable cases.—*Rhyacophilinæ.*

A.A. Drag-hooks plainly less than half as long as last abdominal segment. Larvæ with transportable cases.—*Glossosomatinæ.*

## SUB-FAMILY RHYACOPHILINÆ.

DESCRIPTION OF LARVÆ.—The head is long and flattened, truncate at the cephalic margin. The abdomen is depressed, with deep constrictions at the sutures; the prolegs are well developed, and extend parallel to the axis of the body; their claws are long. The maxillary lobes are long and slender.

### RHYACOPHILINÆ.

A. Apparently two pairs of well-developed drag-hooks. Conspicuous dark-brown pattern passes transversely across middle of head.—*Rhyacophila fuscula.*

A.A. Apparently but a single pair of well-developed drag-hooks. No transverse pattern across middle of head.—*Rhyacophila torva.*

## Rhyachophila Fuscula.

Larval Habitat.—The species is common throughout the region in all fast-running streams with stony bottoms. They are numerous in the permanent streams on the upland hills, but are far more common in the stony gorges near the lake's level.

Larval Habitat.—Until the prepupal state is reached the larvæ build no cases, but crawl naked beneath the stones of the stream's bottom. For life in this situation the flat body and wedge-like head of the larvæ are well adapted, and any form of portable case would be an incumbrance that would make its mode of life impossible.

Food of Larvæ.—Examinations of stomachs indicate that the larvæ live on a mixed diet of animal and vegetable food, with animal material taken in greatest abundance. Only one stomach examined contained nearly pure contents of the filamentous algæ, *Cladophora*. Two stomachs contained a little *Cladophora* mixed with *Chironomid* larvæ; and six stomachs contained nothing but *Chironomid* larvæ. In all cases where *Chironomid* larvæ were found they were swallowed whole, with no mastication whatever.

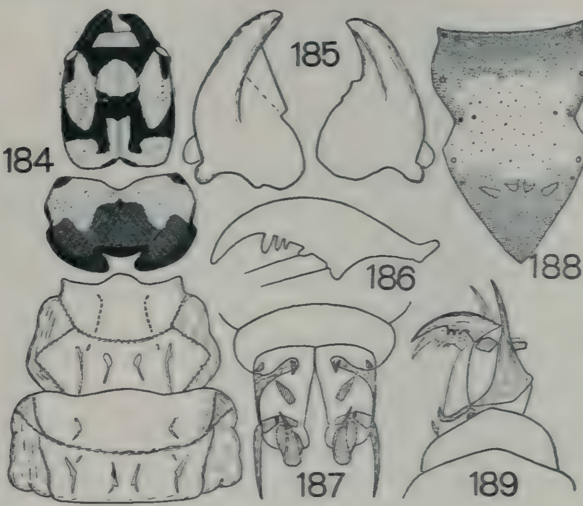
Prepupal Habits.—In preparing to pupate the larva makes the first case of its life—not a portable or close-fitting case like those made by most Trichopterous larvæ, but a roomy corral-like inclosure of pebbles. Inside of the corral the larva spins a puparium-like sheet of silk closely about itself. Within this case transformation takes place.

Period of Emerging.—Specimens were taken on the wing from the latter part of May until the middle of July. It is probable, however, that more careful collecting will discover adults emerging during the greater part of the summer.

Description of Larva.—Length, 20 mm. Color in life, dark-green, changing to brown in alcoholic specimens.

*The Head.*—The ground color is straw yellow, with dark-brown markings subject to slight variation, figure 184. Behind each eye there is an elongate subcutaneous mark of jet black; at the caudal margin of each side of the head there is a jet black mark. On the ventral surface the head is straw yellow, except

bordering the mouth parts, where it shades into brown. The mandibles are black and differ in form, as in figure 185. The labrum is small and is very weakly chitinized.




RHYACOPHILA FUSCULA.

184. Larva. Head and thorax.
185. Larva. Mandibles.
186. Larva. Drag-hook.
187. Larva. Prolegs, ventral view.
188. Larva. Frons.
189. Larva. Prolegs, lateral view.

*The Thorax.*—The chitinous dorsum of the prothorax is straw yellow, marked with dark-brown, as in figure 184. Each episternum is extenuated forward into an upturned spine-like projection which bears a seta at its tip. The ventral surface is free from chitinous plates and is without a horn.

On the meso- and meta-thorax dorsal chitinous plates are lacking. The pleural sutures are deeply sunken, giving a bulbous form to the bordering integument above the bases of the coxæ.

*The Abdomen.*—The abdomen is somewhat flattened and the sutures are deeply constricted, giving a decidedly corrugated appearance. External gills are entirely absent—spacing-humps and lateral fringe are lacking. The drag-hooks are well developed; each movable claw, figure 186, has three teeth and two prominent setæ on its lower surface; above the claw just back of the hinge there is an obtuse chitinous projection, figure 189, and at the base of each proleg there is a long rapier-like projection, figure 189;

on the under side of the proleg near the base there is a chitinous hook directed backward, figures 187, 189.

In a few of the alcoholic specimens examined there are finger-like anal gills. It seems probable that anal gills are constant in the species, but are protruded in preserved specimens only under exceptional conditions.

THE CASE.—As previously stated, the larva makes no case until it begins to prepare for pupation. It then crawls within some crevice between large stones and builds a fence-like wall of pebbles about itself. The fence is oval in outline and is many times larger than the body of the insect. Inside its inclosure the larva spins about itself a close-fitting, parchment-like sheet of silk, superficially resembling the puparium of the higher Diptera. Here transformation takes place.

## RHYACOPHILA TORVA.

LARVAL HABITAT.—The half-dozen larvaæ which have been collected in the region were taken in three of the nearby gorges leading into the Cayuga Lake Valley. The large number of adults occurring in all of the gorges indicates that the species is a common one in the swift waters of the region.

LARVAL HABITS.—When collected our specimens were not distinguished from *R. fuscula,* which the species probably closely resembles in habits.

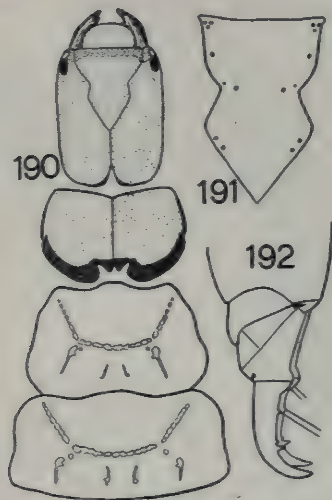
PREPUPAL HABITS.—The prepual habits of the species were not observed.

PERIOD OF EMERGING.—Adults are on the wing during the month of June.

DESCRIPTION OF LARVA.—Length, 20 mm. Head, long and flat, with parallel sides.

*The Head.*—The color of the head is straw yellow, shading into brown behind the mouth parts; behind each eye there is a jet black subcuticular mark, and the caudal margin is narrowly bordered with black, figure 190. The labrum is very weakly chitinized; both mandibles have long teeth, much more deeply notched than those of *R. fuscula;* the mandible of the left side is broader than that of the right side.

*The Thorax.*—The prothorax above is straw yellow, with a caudal margin of deep black; each episternum is extended forward in a spine-like process which has a black dorsal spot; the legs are straw yellow.




RHYACOPHILA TORVA.

190. Larva. Head and thorax.
191. Larva. Frons.
192. Larva. Prolegs, lateral view.

The meso- and meta-thorax are brown in alcoholic material, marked with light yellow, as in figure 190; the second and third pairs of legs are almost white.

*The Abdomen.*—The abdomen is narrower and less flattened than that of *R. fuscula,* the constrictions between segments are not quite so deep, and dorsal furrows of the integument are absent. Each segment has a similar dorsal pattern of light color, as shown in figure 190. The drag-hooks, figure 192, are slender and very simple compared to those of *R. fuscula;* there are no lateral spine-like elongations of the chitin, no dorsal humps at the base of the claws, and no ventral back-turned hooks. The drag-hooks are long and slender and comparatively weak.

Description of Case.—We have made no observations on the case-building habits of the species. Vorhies, who reared it in Wisconsin, states that "the larva lives in a loosely-built case of gravel," and "at the time of pupation this becomes a strong, irregu-

lar hemi-ellipsoid, measuring 10 mm. wide by 15 mm. long." In our collection a single specimen in the prepupal state is inclosed in a puparium-like sheet of silk, like that made by *R. fuscula.*

## SUB-FAMILY GLOSSOSOMATINÆ.

DESCRIPTION OF LARVÆ.—The head is rounded, not long and flattened. The abdomen is round in cross-section, with normal inter-segmental constrictions. The prolegs are short and extend at right angles to the long axis of the body; their claws are weak. The maxillary lobes are short and broad.

### GLOSSOSOMATINÆ.

A. Meso- and meta-notum each with a pair of chitinous plates.—*Agapetus.*

A.A. Meso- and meta-notum entirely soft.—*Glossosoma.*

## GLOSSOSOMA AMERICANUM.

LARVAL HABITAT.—The larvæ are found in all swift waters of the region, but reach their greatest abundance in the riffles of the upland streams. In the parts of streams with stony bottoms in the McLean and Freeville swamps the larvæ occur in extraordinary abundance, their cases completely covering the sides of nearly all submerged stones.

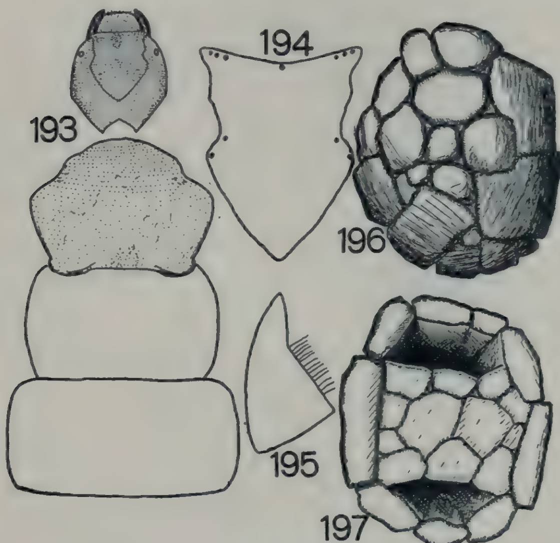
LARVAL HABITS.—From the time of hatching until the prepupal stage the larvæ live singly on the stones of the stream's bottom. Before pupating they congregate in dense colonies on the sides and bottom of stones, with their cases placed edge to edge—sometimes one on top of another. It is during this prepupal stage that the larvæ are most often encountered.

FOOD OF LARVÆ.—Stomachs of a large number of specimens were examined. All contained a light-colored material, the cellular nature of which could not be determined.

PREPUPAL HABITS.—In the prepupal state the larvæ develop a gregarious habit—large numbers congregating in small areas. At this time the floor of the case is cut away and the entire rim of the cup-like roof is securely glued to some solid support. Under this cover the puparium-like cover is spun around the larva.

Period of Emerging.—The species is found as larvæ, pupæ, and adults during the entire summer.

Description of Larva.—Length, 9 mm. In cross-section the body is round. It assumes a curved position, especially marked toward the caudal end of the abdomen.




GLOSSOSOMA AMERICANUM.

193. Larva. Head and thorax.
194. Larva. Frons.
195. Larva. Mandible.
196. Case of larva, dorsal view.
197. Case of larva, ventral view.

*Head.*—The head is small compared to the thoracic segments. It is light-brown without a pattern, except a light-colored area around each eye and indistinct muscle-attachment marks. The mandibles, figure 195, are alike; each has a sparse fringe of pale hairs on its inner margin; in color they are brown. The labrum is shown at the base, with pale outer margins which bear numerous short, light-colored hairs.

*Thorax.*—The prothorax, figure 193, is heavily chitinized above; it is nearly uniform brown in color; on the ventral side there is a brown chitinous plate covering the entire lower surface of the segment; the horn is absent.

The meso- and meta-thorax are without chitinous dorsal plates.

Each of these segments bears an indistinct pattern of pale, narrow marks on its soft dorsal surface.

*Abdomen.*—The abdomen is without external gills. The prolegs are turned at right angles to the axis of the body, and bear drag-hooks of extremely small size, which are apparently put to but little use.

Description of Case.—The case of the larva, figures 196, 197, is made of small pebbles or large sand grains. In form it appears much like a diminutive turtle. On the lower side, figure 197, there is a floor of sand grains built across the middle of the case, leaving the two ends open on the bottom, but completely covered on the upper surface. This case is freely movable over the surface of rocks.

The case of the pupa differs from the case of the larva only in having no floor. The rim of the case is tightly cemented to some submerged rock, and inside of the inverted cup thus formed the cocoon is spun and pupation takes place.

### Genus Agapetus.

An unreared species of the subfamily Glossosomatinæ, which agrees well with published European descriptions of the genus Agapetus, was collected in Michigan Stream above Spencer Lake.

The larvæ differ from the larvæ of the genus Glossosoma in having a pair of large chitinous shields on the mesothorax and a pair of smaller shields on the metathorax. The prolegs and drag-hooks are larger than those of Glossosoma.

The cases are similar to those made by Glossosoma, but larger pieces of gravel are used in their construction.

## FAMILY HYDROPTILIDÆ.

This family contains the most minute members of the order Trichoptera. For this reason, no doubt, it is the most neglected family in the order. Scarcely the first step has been taken toward a knowledge of the immature stages in America, and even the adults are most imperfectly known. In the present stage of our knowledge no attempt at classification is possible.

The tiny larvæ inhabit standing or flowing waters, and often occur in very great numbers. Often their cases completely cover

the edges of rocks in swift streams, or hang in masses in waving tufts of Cladophora.

The cases of the described species are all portable, except those of *Ithytrichia confusa,* which is tightly cemented to rocks in moving water. The cases vary greatly in form in different species. For the most part they are made of pure silk, but some have a sparse interweaving of sand grains or filaments of green algæ.

Description of the Larvæ.—The mandibles are asymmetrical. The antennæ are large, almost as long as the mandibles. Each thoracic segment bears a four-cornered shield. The prosternal horn is lacking. The middle of the abdomen is much larger than the thorax; spacing-humps are absent. The dorsal surface of the abdominal segments often bears chitinous plates. The prolegs are short, with short, stout claws.

The chitinous armature of the larvæ offers excellent characters for classification which, together with the interesting habits of the species, offers a promising field for future investigation.

# BIBLIOGRAPHY.

A complete bibliography of the writings on the order Trichoptera is far beyond the scope of the present work. For more complete references to the literature the student is referred to "Die Trichopteren-Literatur von 1903 (resp. 1907), bis Ende 1909," by Georg Ulmer, Zeitschrift für wissenschaftliche Insektenbiologie, 1911 and 1912. This work reviews all writings on the order that appeared during the period between 1903 and 1909.

A more lengthy bibliography of the Trichoptera of the world appears in "Genera Insectorum," Ulmer, 1907.

Bibliographical references to the adults of the American fauna will be found in "Catalogue of the Neuropteroid Insects of the United States," by Nathan Banks, American Entomological Society, 1907.

A bibliography of the more important works is contained in "Studies on the Trichoptera of Wisconsin," by Charles T. Vorhies, Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, 1909.

The most important key to the North American Trichopterous larvæ, Krafka, 1915, is quite satisfactory for determining most species to the family or subfamily, but makes no attempt to classify genera and species.

A number of authors have published more or less on the habits of caddis-worms. No doubt the most important of these is the work of Dr. Vorhies, 1909, in which are described the immature stages of nineteen species, with careful notes on their habits.

Preceding the work of Dr. Vorhies, Miss Cora H. Clarke published two articles, 1882 and 1901, in which she described and figured the cases of more than twenty species. Many of the determinations in this article go no farther than the genus, and sometimes no attempt at classification is made. The figures of the cases are good and many accurate notes on the habits of the larvæ accompany them. That the author used more than usual care in observing her specimens is shown by her figure of the respiratory grating of the case of Neophylax (unnamed in her article) and her mention of the "spinnaret" of the larva "Plectronemia." Without doubt this was a species of Phylocentropus.

There are no more accurate figures and notes on the cases of the larvæ and pupæ of Trichoptera than are furnished by the work of Miss Clarke.

The habits of the net-spinning caddis-worms of swift water have been carefully described by Miss Noyes, 1914. A more detailed account of the net-spinners, together with a description of the larvæ and pupæ, has been prepared by Miss Noyes and is forthcoming in a bulletin of the New York State Museum.

Dr. Cornelius Betten has prepared a careful monograph of all stages of North American Trichoptera, which will soon appear as a bulletin of the New York State Museum. After the appearance of this work much of the difficulty of determining species will be removed and, no doubt, the study of the order will be greatly stimulated.

The bibliographical references in this paper cover all of the important writings on the immature stages of North American Trichoptera known to us. Many excellent papers have appeared on the immature stages of the European species, reference to which will be found in the aforenamed bibliographies. Much use has been made of many of these works in the preparation of the present paper, especially to the part on Trichoptera, Heft 5/6, of the "Süsswasserfauna Deutchlands," by Georg Ulmer.

---

A List of the More Important Writings on the Immature Stages of North American Trichoptera.

Betten, C. 1901. Aquatic Insects of the Adirondacks. Bull. 47. N. Y. State Mus. pp. 561-172.

Betten, C. 1902. The Larva of the Caddis-fly, Molanna cinerea. Jour. N. Y. Ent. Soc. X. pp. 147-154.

Clarke, Cora H. 1882. Descriptions of two interesting Houses made by native Caddis-fly larvae. Proc. Bost. Soc. Nat. His. XXII. pp. 67-71.

Clarke, Cora H. 1891. Caddis-worms of Stony Brook. Psyche. VI. pp. 153-158.

Comstock, Anna B. 1903. Ways of the Six-Footed. Boston. pp. 133-138.

Comstock, J. H. 1901. Insect Life. New York. pp. 79-80, 148-152.

Comstock, J. H. 1901. On the Emergence of a Caddis-fly from the water. Am. Nat. XXI. p. 480.

Comstock, J. H. 1899. Manual for the Study of Insects. Ithaca. pp. 186-190.

FIELDE, A. M. 1887. On an Aquatic Larva and its Case. Proc. Acad. Nat. Sci. Phil. p. 293.

HILL-GRIFFIN, Annie Laura. 1912. New Oregon Trichoptera. Ent. News. XXII. pp. 17-21.

HOWARD, L. O. The Insect Book. New York. pp. 195-205.

HOUGHTON, W. 1868. Caddis-worms and their Metamorphosis. Pop. Sci. Rev. VII. pp. 287-295.

KELLOGG, Vernon L. 1905. American Insects. New York. pp. 240-245.

KRAFKA, Joseph Jr. 1915. A Key to the Families of Trichopterous Larvae. Can. Ent. XLVI. pp. 217-225.

LLOYD, J. T. 1915a. Notes on Brachycentrus nigrisoma. Banks. Pomona Jour. Ent. & Zool. VII. pp. 81-86.

LLOYD, J. T. 1915b. Notes on the Immature Stages of some New York Trichoptera. Jour. N. Y. Ent. Soc. XXIII. pp. 201-212.

LLOYD, J. T. 1915c. Wood-boring Trichoptera. Psyche. XXII. pp. 17-21.

LLOYD, J. T. 1915d. Notes on Ithytrichia confusa Morton. Can. Ent. XLVII. pp. 117-121.

LLOYD, J. T. 1915e. Notes on Astenophylax argus Harris. Jour. N. Y. Ent. Soc. XXIII. pp. 57-60.

MARSHALL, W. S. & VORHIES, C. T. 1905. The repair and rebuilding of the larval cases of Platyphylax designatus. Walk. Biol. Bull. IX. pp. 232-244.

MARSHALL, W. S. & VORHIES, C. T. 1906. Cytological studies on the Spinning Glands of Platyphylax designatus Walker. Intern. Monatschr. f. Anat. u. Physiol. XXIII.

MARSHALL, W. S. 1907. The early history of the cellular elements of the ovary of a Phryganid. Platyphylax designatus Walk. Ztschr. wiss. Zool. LXXXVI. pp. 214-237.

MURPHY, Helen E. 1919. Observations on the Egg Laying of the Caddis-Fly Brachycentrus nigrisoma Banks, and on the habits of the young larvae Jour. N. Y. Ent. Soc. XXVII. pp. 154-159.

NAKAHARA, W. 1917. On the Physiology of the Nucleoli as seen in the Silk-Gland Cells of certain Insects. Jour. Morph. XXIX. pp. 55-68.

NEEDHAM, J. G. 1903. Aquatic Insects in New York State. N. Y. State Mus. Bull. LXVIII. pp. 205-206.

NEEDHAM, J. G. 1903. Remarks on Hydroptilid larvae and their Metamorphosis. Zool. Anz. XXVII. pp. 108-110.

NEEDHAM, J. G. 1908. Report on the Entomological Field Station conducted at Old Forge, N. Y., in the summer of 1905. N. Y. State Mus. Bull. CXXIV. pp. 12, 14.

NEEDHAM, J. G. & LLOYD, J. T. 1915. The Life of Inland Waters. Ithaca. pp. 260-261, 214-218, 371-372.

NOYES, Alice Ayr. 1914. The Biology of Net-Spinning Trichoptera of Cascadilla Creek. Annals Ent. Soc. Am. VII. pp. 251-272.

Noyes, Alice Ayr. 1915. The Proventriculus of a Hydropsyche larva. Jour. Ent. & Zool. VII, pp. 34-44.

Shelford, Victor E. 1913. Animal Communities in Temperate America as illustrated in the Chicago Region. Geog. Soc. Chicago Bull. V. (Numerous brief references).

Simpson, C. B. 1903. The Log-Cabin Builder (Limnephilus indivisus Walk.). Proc. Ent. Soc. Wash. V. pp. 98-100.

Simpson, C. B. 1903. Photographing nets of Hydropsyche. Proc. Ent. Soc. Wash. V. pp. 93-94.

Sleight, Charles E. Relations of Trichoptera to their Environment. Jour. N. Y. Ent. Soc. XXI. pp. 4-8.

Vorhies, C. T. 1905. Habits and Anatomy of the Larva of the Caddis-fly. Platyphylax designatus Walker. Trans. Wisc. Acad. Sci. Arts. Letters. XV. pp. 108-123.

Vorhies, C. T. 1908. The development of the nuclei of the spinning gland cells of Platyphylax designatus Walker. Biol. Bull. XV. pp. 54-62.

Vorhies, C. T. 1909. Studies of the Trichoptera of Wisconsin. Trans. Wisc. Acad. Sci. Arts. Letters. XVI. pp. 647-738.

Vorhies, C. T. 1913. Trichoptera collected under unusual conditions. Ent. News. XXIV. p. 84.

---

Specific descriptions of the following North American larvæ have appeared in previous publications. (*) Indicates species also described in the present work.

| Species. | Author. |
|---|---|
| Astenophylax argus* | Lloyd. 1915e. p. 57. |
| Brachycentrus nigrisoma* | Lloyd. 1915a. p. 81. Murphy. 1919. p. 154. |
| Chilostigma difficilis* | Lloyd. 1915b. p. 208. |
| Ganonema nigrum=* (americanum?) | Lloyd. 1915c. p. 17. |
| Grammataulius bettenii | Hill-Griffin. 1912. p. 18. |
| Helicopsyche borealis* | Vorhies. 1909. p. 681. |
| Hydropsyche alternans | Vorhies. 1909. p. 707. |
| Ithytrichia confusa | Lloyd. 1915d. p. 117. |
| Lepidostoma wisconsinensis | Vorhies. 1915. p. 685. |
| Leptocella uwarowii | Vorhies. 1915. p. 695. |
| Leptocerus ancylys* | Vorhies. 1915. p. 691. |
| Leptocerus dilutus | Vorhies. 1915. p. 688. |
| Leptocerus tarsi-punctatus | Vorhies. 1915. p. 694. |

## BIBLIOGRAPHY.


| Species. | Author. | Species. | Author. |
|---|---|---|---|
| Limnophilus combinatus =* | Vorhies. 1909. p. 661. | Neuronia postica* | Vorhies. 1909. p. 658. |
| (rhombicus) | Lloyd. 1915b. p. 203. | Phryganea interrrupta* | Vorhies. 1909. p. 654. |
| Limnophilus indivisus | Lloyd. 1915b. p. 205. | Phylocentropus maximus | Vorhies. 1909. p. 711. |
| Limnophilus submonifer* | Vorhies. 1909. p. 666. | Phylocentropus lucidus | Betten. 1901. p. 565. |
| Molanna cinerea | Betten. 1901. p. 564. 1902. p. 147. | Platyphylax designatus* | Vorhies. 1905. p. 108. 1909. p. 672. |
| Molanna uniophila | Vorhies. 1909. p. 705. | Platyphylax subfasciatus | Vorhies. 1909. p. 678. |
| Mystacides alafimbriata | Hill-Griffin. 1912. p. 19. | Rhyacophila torva* | Vorhies. 1909. p. 713. |
| Neophylax automnus* | Vorhies. 1909. p. 669. | Setodes grandis* | Vorhies. 1909. p. 699. |
| Neuronia pardalis* | Lloyd. 1915b. p. 201. | Triaenodes flavescens | Vorhies. 1909. p. 702. |

BULLETIN No. 22 1922 ENTOMOLOGICAL SERIES, No. 2

# BULLETIN
of the
# LLOYD LIBRARY
of
## BOTANY, NATURAL HISTORY PHARMACY AND MATERIA MEDICA

FOUNDED, ENDOWED AND MAINTAINED
BY
CURTIS G. LLOYD

ENTOMOLOGICAL SERIES, No. 2

# NOTES ON THE BIOLOGY OF SOME OF OUR NORTH AMERICAN SPECIES OF MAY-FLIES.*

HELEN E. MURPHY

I. The Metamorphosis of May-fly Mouth Parts.

II. Notes on the Biology of May-flies of the Genus Baetis.

*Contribution from the Limnological Laboratory, Cornell University.

# CONTENTS

## PART I



## PART II

# I—The Metamorphosis of May-fly Mouth Parts

## I—INTRODUCTION

This paper is a study of the metamorphosis of May-fly mouth-parts. It follows the development of mouth-parts in the embryo, and their changes in form and structure in nymph, subimago and imago.

The life cycle of a May-fly is divided into two main parts: a relatively long period of development spent in the water; and a brief aerial existence devoted entirely to reproduction. The female either drops the eggs at the surface of swift or stagnant water, or, as in *Baetis,* creeps into the water, and deposits them on stones in tiny, single-layered patches. From the time of hatching, nymphal activities are concentrated mainly on food and growth. Indeed, all the eating for a life time takes place during this stage. When nymphal life is completed, the insect usually swims to the surface of the water, sheds its skin, and flutters through the air to some support. There it sits, with wings uplifted, and fore legs thrust stiffly forward, waiting for the subimaginal molt. Then the imago or true adult emerges and joins an assemblage of its own species. A mating dance follows. They rhythmically rise and fall in flight, soaring aloft to various heights and falling ecstatically with wings outspread. Soon the females leave the throng one by one, and fly away to deposit their eggs. The males prolong the joyous revel until exhausted. A little later the dead bodies of all are washed about in the water.

## II—TECHNIQUE

Embryology. The principal material used for the study of the embryology of the mouth-parts has been *Baetis posticatus.* The eggs were treated as follows:

| | |
|---|---|
| Hot water | 1 minute |
| Bouin's fluid | 12 hours |
| 65% alcohol | 72 hours |
| 75% alcohol | 24 hours |
| 80% alcohol | 24 hours |
| 85% alcohol | 24 hours |
| 90% alcohol | 24 hours |
| 95% alcohol | 24 hours |
| Abs. alcohol | 1 week |

The absolute alcohol hardened the embryos so that the outer membranes could be removed without injury to the specimens. The eggs were stained 24 hours with hydrochloric carmine, and differentiated with acid alcohol. Then they were

transferred to weak glycerine, where dissections were made with No. 12 Sharp's cambric needles under a high power binocular microscope. When mounted in weak glycerine the embryos could be rolled in various directions without injury. For permanent preparations the specimens were dehydrated through the alcohols, cleared in equal parts of absolute alcohol and cedar oil for 12 hours, cedar oil for 6 hours, and xylol for 1 hour. Then they were mounted in balsam.

MUSCULATURE. For a study of the nymphal musculature, dissections of newly molted specimens were made in glycerine. In toto preparations were made by killing the specimens in formalin, dehydrating through the alcohols, clearing in xylol, and mounting in balsam. Serial sections were cut 10 microns in thickness, and stained with Delafield's hematoxylin and picro-fuchsin.

EXTERNAL MORPHOLOGY. Specimens used for study of the external morphology were boiled in 5% KOH until only the chitinized parts were left. Then they were stained with picro-carmine.

INTERNAL METAMORPHOSIS. The material used for the internal metamorphosis of the mouth-parts was *Hexagenia recurvata*.

For histological examination, specimens were treated as follows:

| | |
|---|---|
| Hot water | 1 minute |
| *Helly's fluid | 12 hours |
| Running water | 12 hours |
| 67% alcohol | 24 hours |
| 82% + tincture of iodin | 72 hours |
| 90% alcohol | 12 hours |
| 95% alcohol | 12 hours |
| Abs. alcohol | 12 hours |
| Xylol | 6 hours |
| Xylol-paraffin | 6 hours |
| Pure paraffin | 3 hours |

Sections were cut 9 microns thick, and stained from water with Giemsa's blood stain (1 drop: 1 cc. $H_2O$) for 45 minutes. They were washed in distilled water until a faint pinkish tinge appeared; then dehydrated through the alcohols, cleared in cedar oil, passed through xylol, and mounted in neutral balsam. Material fixed in Zenker's fluid and stained with Delafield's hematoxylin and eosin gave good results for muscle degeneration, but did not differentiate the plasma cells.

PLASMA SMEARS. For plasma smears from nymph, subimago and imago, a thoracic leg was dipped in 95% alcohol, allowed to dry, and then severed. The

*HELLY'S FLUID: Potassium dichromate, 2.5 gms.; sodium sulphate, 1 gm.; mercuric chloride, 3 gms.; .6% sodium chloride solution, 100 cc.; formalin, 5 cc. added just before using. This fluid preserves the granules in the plasma cells and permits their identification in sections.

drop of fluid that exuded was touched to a glass slide and the smears made in the usual manner. They were fixed in absolute alcohol for 15 minutes. This has the added advantage of dissolving the fat. Smears were stained with Giemsa's blood stain (1 drop: 1 cc. distilled $H_2O$) for 20 minutes, and rinsed in distilled water until the better-spread portions had a pinkish tint. Smears were also fixed in Helly's fluid and used as checks on the ordinary smears.

# III—HISTORICAL

The earliest work on the embryology of May-fly mouth-parts is probably that published by Burmeister in 1848. He mentions the rudiments of the mouth-parts in *Palingenia horaria* twelve days after oviposition. N. Joly in 1876 wrote a paper on the embryology of *Palingenia virgo*. He figures the mouth-parts during the later stages of development, and says that they are modified considerably before they reach their ultimate form. Heymons, 1896, gives general figures of the mouth-parts of *Ephemera vulgata*. He erroneously calls the mandibular tusk the "morphological equivalent of a mandibular palp."

The greater part of the work on the mouth-parts of May-fly nymphs has been published by systematists. Among the earlier workers, Pictet 1843, Hagen 1849-90, and Eaton 1883-6, stand pre-eminent. Needham 1901-8 published a key for the separation of our common North American genera of May-fly nymphs, and grouped them in three sub-families. A large number of nymphs were also described from bred specimens. His life-history work was followed by that of Morgan 1911, and Clemens 1913-17. Morgan 1913 gives a very complete bibliography and historical review of the entire field. She treats the modifications of the mouth-parts as an adaptation to environment. The main lines of specialization in the three sub-families are sketched, and the details of the mouth-parts. There is a discussion of food, and the function of the individual mouth-parts in feeding.

The atrophy of May-fly mouth-parts during aerial life has long been a matter of observation among students of this group. In 1661 Johann Swammerdam writes: "In the adult condition these insects (Ephemeridae) do not eat, as is the case with various other insects. The mouth-parts and alimentary canal of the winged fly are completely useless and empty." Wolter, 1883, speaks of the fusion of the labial segments in the imago. In 1907 Sternfeld says that degeneration begins in the late nymph. Loss of segmentation is the main difference in the mouth-parts of subimago and imago. He concludes that the form of the mouth-parts is highly variable among the different genera.

# IV—MOUTH PARTS OF THE EMBRYO

The eggs of *Baetis sp.* are laid on stones in swift water in single-layered masses of eighty-five to three hundred. They are covered with a thready, viscid substance which causes them to adhere to each other and to the stones. An individual egg (Pl. I, fig. 1) is ovoid in shape and measures .152 mm. x .081 mm. The chorion is yellowish and slightly pitted.

Eggs brought into the laboratory hatched eleven days* after oviposition. The ventral plate (Pl. I, fig. 2, Vp) appears the second day, and differentiates within twenty-four hours into primitive streak and amnion. One day later the head, thoracic and abdominal regions are distinct (Pl. I, fig. 3). Then the mouth-part rudiments appear almost simultaneously (Pl. I, fig. 5). Thoracic legs are differentiated and abdominal segmentation is complete on the sixth day. Embryonic development is finished five days later. Straightening the legs and flexing the abdomen, the nymph emerges through a middorsal slit in the chorion. It begins to eat immediately.

## DEVELOPMENT OF THE MOUTH-PARTS.

Clypeo-labrum. The clypeo-labrum arises as an evagination between the procephalic lobes. On the fifth day, at the time of origin of the paired mouth-parts, it is a median hemispherical papilla (Pl. I, fig. 5, Clp. Lm). The clypeo-labral suture (Pl. I, fig. 6) is evident on the eighth day. The anterior border of the labrum becomes rounded and emarginate. The sensory hairs appear as tiny papillae (Pl. I, fig. 7) on the tenth day. They are elaborated just at hatching (Pl. I, fig. 8).

Mandibles. The mandibles arise as simple cone-shaped papillae during the fifth day of embryonic development (Pl. I, fig. 5, md). A protuberance soon appears at the inner apical region (Pl. I, fig. 9, ia). A little later the mid-apical region is indistinctly divided into two parts (Pl. I, fig. 10, c). As the mandible elongates, the outer lateral region becomes less rounded, and the inner lateral portion slightly bulged. The eighth day the apical portion begins to swing toward the mid-ventral line. At that time the two mid-apical parts, destined to become the nymphal canines, are more distinctly defined (Pl. I, fig. 11, c). Serrations appear at the tips of the canines, and the molar surface is indicated on the inner-lateral bulge by tiny papillae. The ginglymous articulations on the dorsal and the ventral surface are evident, and the inner-apical lobe is movable. The molar papillae increase in size and become confluent to form transverse ridges. These ridges are wedge-shaped, with the apex pointing upward. At hatching the mandible (Pl. I, fig. 12) is dorso-ventrally flattened, and the molar surface (ms.) inclined obliquely ventrad. The two canines (oc., ic.) each possess four teeth at the tip. Molar surface, canines, ginglymous articulation (ga.), and movable inner lobe (il.) are heavily chitinized.

---

*Twenty-eight days in the cooler water of the creek.

Hypopharynx. The hypopharynx is evident near the dorsal base of the labium on the eighth day. It then consists of three single papillae: a median papilla between the bases of the two maxillae; and a lateral papilla at either side near the bases of the mandibles. With the forward migration of the mouth-parts, they are crowded together. At hatching, the hypopharynx (Pl. I, fig. 13) is a trilobed structure with sensory hairs.

First Maxillae. The first maxillae arise as simple cone-shaped papillae (Pl. I, fig. 5, mx.1.) similar to those of the mandibles, but they elongate more rapidly. A lobe soon appears on the outer lateral region (Pl. I, fig. 14, ol). This is the future palp. The apical region becomes rounded and flattened. Then this area subdivides into two parts (Pl. I, fig. 15, oa, ia). The outer apical region differentiates into the galea; the inner into the lacinia. As the galea-lacinial portion elongates, the cleft between the two parts increases. On the eighth day segmentation in the palp and cardo-stipital region is indicated by notches (Pl. I, fig. 16). Galea and lacinia gradually fuse. The cardo becomes distinct, but neither the palpifer nor the suture between the stipes and galea-lacinia is differentiated. Spines appear as cone-shaped papillae at the distal part of the galea-lacinia on the tenth day. At hatching, hairs are evident on the distal palp segment (Pl. I, fig. 17, Mx. Plp), and the inner galea-lacinial region (Pl. I, fig. 17, Ga Lc). This part is chitinized heavily; the palp very weakly.

Second Maxillae or Labium. The second maxillae arise as cone-shaped papillae on the fifth day (Pl. I, fig. 5, Mx2). They become bi- and tri-lobed (Pl. I, fig. 18) at the same time as the first maxillae. On the seventh day a secondary, lower-median lobe appears (Pl. I, fig. 19, lm) and the two second maxillae migrate toward the mid-ventral line. The secondary lobes fuse first (Pl. I, fig. 20, lm). At that time the galea and lacinia are distinct (Pl. I, fig. 20, Ga, Lc). There are also traces of segmentation in the palp (Pl. I, fig. 20, Lb Plp), and indications of the submentum below the fused lower-median lobes. The large central portion becomes the mentum of the nymphal labium (Pl. I, fig. 21, M), the lacinia the glossa (gl) and the galea the paraglossa (Pgl). A third distal segment of the palp is incompletely differentiated (Pl. I, fig. 21, Lb Plp). Spines and hairs are elaborated at the same time as those of the first maxilla.

The early appearance of the inner lobe on the mandible, and the fact that it is articulated, but has no musculature, suggests the possibility of a primitive structure. It occupies the same relative position on the mandible as the lacinia mobilis of certain crustacea (Mysis, Arolana). Embryological evidence indicates that the movable inner lobe of the May-fly mandible is a lacinia.

A mandibular palp is present at no stage of embryonic development. *Ephemera vulgata* used by Heymons for his embryological study is a burrowing May-fly. The mandibular tusk, which he calls the "morphological equivalent of a mandibular palp" is a secondary modification appearing at the time of differentiation of the canines and molar region. It is not lateral in origin, but arises from the outer apical region.

# V—MOUTH PARTS OF THE NYMPH

May-fly nymphs are divided systematically into three sub-families: the Ephemerinae, Heptageninae, and Baetinae. The Ephemerinae (Pl. II, fig. 23) are mud or gravel dwellers. The bodies of those that live in mud are elongate and cylindrical in form, with feet adapted for scooping, and mandibular tusks for lifting. The Heptageninae (Pl. II, fig. 22) are found in running water, generally clinging to the under surface of stones. The head, thorax, abdomen and lege are strongly depressed. The head margins are flaring to deflect the current. The more generalized of the Baetinae (Pl. II, fig. 24) inhabit the still waters of ponds and pools. Some of this group intermingle with the Heptageninae in the swift waters; others associate with the Ephemerinae on the sediment-covered bottom in mud and silt.

The food of May-fly nymphs mainly consists of algae, diatoms, and the dead tissues of higher plants. Members of the Heptageninae have mouth-parts adapted for scraping algae and diatoms from the stones. Rhithrogena uses the blade-like distal segment of the maxillary (Pl. V, fig. 69, Mx Plp) and labial palp as a rake. The labrum in front, maxillae at the sides, and labium in the rear brush the food into the mouth cavity. There it falls upon the molar surface of the mandibles, and is ground. The Ephemerinae grind up the mud and silt and digest the diatoms and plant waste. Among the Baetinae, some rasp and strip pieces from roots and stones; some grind the silt in the manner of the bottom-living Ephemerinae; and others have diverse brushes or bristles for use in swift water.

## MUSCULATURE.*

### I. Labrum.

*Abductor* (L'elevateur du labre, Str-D; musculus levator labri, Bauer). The abductors of the labrum (Pl. III, fig. 35, Abd.) are a pair of median muscles originating in the front of the head between the antennae, and inserted in the proximal portion of the labrum by a very short tendon.

*Adductor*. The adductors of the labrum (Pl. III, fig. 35, ad) are two two-headed muscles inserted by a long tendon, one at either side of the basal angle. They are attached to the front of the head just below the bases of the antennae.

---

*Owing to the various systems of nomenclature, uniformity in designating the muscles of the mouth-parts is impossible at present. Since the musculature for May-flies is similar to that reported for Gryllus by DuPorte (Ann. Ent. Soc. Am. 13:19-23), I have adopted his system to avoid further confusion. Whenever possible, nomenclature previously used is indicated.

### Epipharynx.

The epipharyngeal muscles (Pl. III, fig. 35, epl, ep2) are two cone-shaped muscles attached to the inner surface of the labrum and epipharynx near the median line.

### II. Mandible.

*Flexor.* The flexor of the mandible (Pl. III, fig. 34, Fl; Pl. II, fig. 26, Fl) is a large three-parted muscle attached to the anterior part of the body of the tentorium (Tn), and inserted at the outer wall of the body of the mandible.

*Adductor.* (Adducteur des mandibules, Str.-D.; flexor mandibulae, Burm.; musculus flexor mandibulae, Bauer). The adductor of the mandible is a strong pyramidal shaped muscle (Pl. III, fig. 34, ad), its attachment filling the anterior part of the head capsule as far forward as the eye and upper part of the brain. It is inserted by a strong sheath-shaped tendon at the upper, inner angle of the dorsal surface of the mandible (Pl. II, fig. 26, ad).

*Abductor.* (Abducteur de la mandibule, Str.-D.; extensor mandibulae, Burm.; musculus extensor mandibulae, Bauer). The abductor of the mandible (Pl. III, fig. 34, Abd; Pl. II, fig. 26, Abd) is a slender muscle inserted at the lower outer-angle of the ventral surface by a short tendon, and attached to the postgena at a level with the top of the eye.

The mandible is attached on its dorsal surface to the postgena by a large heavily chitinized articulation (Pl. II, fig. 26, 25 ga.) and ventrally at its lower inner angle by a much smaller ginglymous joint (fig. 25, 26 ga.; fig. 27). With these two articulations as pivots the mandible rocks toward the median line in a dorso-ventral plane.

### III. Hypopharynx.

*Elevator.* The elevator of the hypopharynx (Pl. III, fig. 36, El) is inserted at the ventral basal angle of the median lobe, and attached to the midlabial apodeme.

*Retractor.* The retractor of the hypopharynx (Pl. III, fig. 36, R) is a long slender muscle inserted on the dorsal surface at the point of fusion of the lateral and median lobe. It is attached to the base of the central plate of the tentorium at the side of the labial retractor.

*Depressor.* The depressor of the hypopharynx (Pl. III, fig. 36, d) is a single muscle attached to the midapical region of the median lobe and inserted in the central apodeme (ap.). With the retractor this muscle aids in opening the pharynx.

*Compressor.* The compressor of the hypopharynx (Pl. III, fig. 36, co) is a mid-lateral muscle attached to the junction of the labium and hypopharynx, and inserted at the central apodeme (ap.). With the elevator it aids in blocking the pharyngeal opening.

In Ecdyurus, one of the Heptageninae, the hypopharynx (Pl. III, fig. 37) is not heavily chitinized and is relatively large. The compressors form a delicate horizontal sheath (co) around the median lobe (m), and the depressors a vertical sheath (d). The lateral lobe (l) is provided with one depressor (d) and two compressors (co).

In Callibaetis (Pl. V, fig. 67) and Baetis (Pl. I, fig. 13) (Baetinae) no musculature is evident within the hypopharynx.

### IV. Maxilla.

*Flexor*. (Musculus flexor anterior, Bauer). The flexor of the maxilla (Pl. III, fig. 38, Fl) is a two-parted muscle attached to the outer edge of the stipes (St) and inserted at the lower part of the central plate of the tentorium.

*Adductor*. (Adducteur de la machoire, Str.-D.; flexor maxillae, Burm.; musculus flexor maxillae Posterior, Bauer). The adductor of the maxilla (Pl. III, fig. 34, ad) is a two-parted muscle inserted at the outer and basal angles of the cardo (Cd). It is attached to the lower surface of the central plate of the tentorium.

*Abductor*. (Musculus flexor superior, Bauer). The abductor of the maxilla (Pl. III, fig. 38, Abd) is a slender two-parted muscle inserted at the lower inner angle of the galea-lacinia (Ga Lc) and attached to the posterior arm of the tentorium.

*Flexor of galea-lacinia*. The flexor of the galea-lacinia (Pl. III, fig. 38, Fl) is inserted at the outer angle of the stipes (St) and attached to the galea-lacinial apodeme (ap).

### Maxillary Palp.

*Extensor*. (Musculus extensor palpi maxillaris, Bauer). The extensor of the maxillary palp (Pl. III, fig. 38, e) originates at the stipital apodeme and is inserted at the outer angle of the base of the first palp segment.

*Flexor*. The flexor of the maxillary palp (Pl. III, fig. 38, f) originates at the stipital apodeme and is inserted at the inner angle of the base of the first palp segment.

The flexor (Musculus flexor articuli palpi maxillaris, Bauer) of the second palp segment (Pl. III, fig. 38, f) originates at the outer basal angle of the first segment, and is inserted by means of a slender tendon into the inner basal angle of the second segment. The extensor of the second palp segment (Pl. III, fig. 38, e) originates at the inner basal angle of the first segment and is inserted into the outer basal angle of the second segment. This system of cross attachments gives greater leverage to the blade-like distal segment. In those forms where

the palp is not used as a scraper, the attachment is on the same side as the insertion.

### V. Labium.

*Retractor.* The retractor of the labium (Pl. III, fig. 39, R) originates at the base of the central plate of the tentorium, and is inserted at the lateral border of the ligula (Lg) near the base of the paraglossa (Pgl).

*Adductor.* The adductor of the labium (Pl. III, fig. 39, ad) originates in the submentum (Sm) near the median line, and is inserted in the proximal border of the ligula (Lg).

*Abductor.* The abductor of the labium (Pl. III, fig. 39, Abd) originates at the basal edge of the tentorium, and is inserted at the outer angle of the distal border of the mentum (M).

### Ligula.

*Adductor.* The adductor (Ad) of the paraglossa (Pgl) is attached at the base of the ligula not far from the median line, and is inserted near the center of the base of the paraglossa. The adductor (ad) of the glossa (gl) originates in the central area of the ligula and is inserted at the base of the glossa.

### Labial Palp.

*Extensor.* The extensor of the labial palp (Pl. III, fig. 39, e) originates at the central apodeme (ap) and is inserted at the outer angle of the base of the first palp segment.

*Flexor.* The flexor of the labial palp (Pl. III, fig. 39, f) originates at the central apodeme (ap) and is inserted at the inner angle of the base of the first segment of the palp.

Within the palp, the extensors (e) arise on the outer side, and the flexors (f) on the inner side of the basal angle, and are inserted into the outer and inner side of the basal angle of the next distal segment.

The exteme development of labial musculature is found among the Heptageninae. The palp muscles are enormously increased in size and their insertion shifted to give greater leverage. The extensor of the palp (e) of Ecdyurus (Pl. III, fig. 40) is inserted far out on the lateral surface of the basal segment. It has no opponent. Within the palp the attachment of the flexor (f) of the second segment extends across the base and along the outer lateral surface of the first segment. The adductors (ad) and abductors (Abd) of the labium are sheath-like bands extending across the fused ligula and mentum. Glossa (gl) and paraglossa (Pgl) each possess one abductor (Abd) and two adductors (ad).

## SURVEY OF THE MOUTH-PARTS.

A survey of the mouth-parts of representatives of the various genera* reveals striking variations in form, and diverse adaptations to similar ecological situations.

### Labrum (Pl. IV).

The main variations in the labrum of May-fly nymphs are in the form of the anterior border, and in the cuticular appendages. Judged from embryological evidence, the more primitive form of border is straight, like that of Ephemerella (fig. 57) and Chirotenetes (fig. 42). There are two lines of deviation from this condition. In the one, the border is notched in the center (Callibaetes, fig. 43; Baetis, fig. 44). In the other, it is extended laterally and incurved like that of Ecdyurus (fig. 46) and Hagenulus (fig. 47). The cuticular appendages consist of hairs and spines. Some forms possess both hairs and spines (Polymitarcys, fig. 41); some like Chirotenetes (fig. 42) have spines only; and others but hairs (Oligoneuria, fig. 45). Spines are characteristic of those forms exposed to swift water. Hairs are peculiar to burrowers or sprawlers in the mud.

The labrum of Hagenulus (fig. 47), one of the Baetinae, is strangely adapted for life in swift water. It is flattened and has an extraordinary lateral extension far beyond the head capsule, simulating the flaring, depressed head of the Heptagenine associates. Among these, the mouth-parts are retracted beneath the outgrowth of the head; in Hagenulus it is the labrum that protrudes, and the head capsule is small. The backward projecting spines at the free posterior margins in Hagenulus doubtless serve for protection.

### Mandible (Pls. II, IV).

*Molar surface*. The primary function of the May-fly mandible is to grind food. For this purpose a molar surface is developed. Among the Ephemerinae there is one prevailing type. The left molar surface of Ephemera (fig. 31) bears eight transverse ridges, the anterior edge of each provided with teeth. Between these ridges are deep gutters. The right molar surface (fig. 32) has seven transverse ridges toothed at the anterior edge. The molar surfaces (fig. 28) move in a dorso-ventral plane, rubbing together the transverse ridges. The teeth extending out into the gutters doubtless serve as strainers for the food. Cast skins show many of the transverse ridges worn smooth, but the teeth still sharp, and clogged with ground food. Among the Baetinae and Heptageninae are two main types of molar surface. In one, the transverse ridges are irregularly serrated (fig. 33), with stiff bristles acting as strainers across the gutters. In the other, the transverse ridges are rounded and knobbed (fig. 29, 30). They

*The exotic specimens were very kindly loaned me by Dr. J. G. Needham.

are broad at the posterior portion, but fray out anteriorly. This is the prevailing type among those forms inhabiting streams with gravel or sand bottom.

The molar surface reaches its maximum of development in Lachlania (fig. 56) and Homeoneuria (fig. 62). Eaton's nameless Chilean nymph (fig. 63) has no molar surface. He suggests that it is predatory.

*Lacinia.* The lacinia of the May-fly mandible has been variously named. Eaton, 1883, writes: "The endopodite is often represented by a slender jointless movable appendage attached to the inner base of the inferior lobe, or sometimes by a tuft of hairs." Folsom, 1900 (p. 107) states: "It is an interesting fact that Heymons '96, distinctly represents a mandibular palp for the larva of Ephemera,—a rare condition; indeed Packard, '98, terms this appendage of nymphal Ephemerids a 'lacinia-like' process, although Heymons states that it is lateral in position, and so figures it." Lestage, 1917, states that a "prostheca" is present. In fig. 1, p. 219, he erroneously labels it a canine and states that the prostheca is absent in that form.

Many varieties of mandibular lacinia exist among the different genera. There are well developed forms. Many of these are articulated at the base (Baetis, fig. 60; Polymitarcys, fig. 50; Siphlurus, fig. 51; Euthyplocia, fig. 59). Others are anchylosed (Choroterpes, fig. 55; Leptophyes, fig. 52; Heptagenia, fig. 53). Some laciniae bear teeth at the apex (Polymitarcys, fig. 50; Leptophyes, fig. 55; Euthyplocia, fig. 59). Long brush-like bristles are present on the lacinia of Leptophyes (fig. 52), Polymitarcys (fig. 50), and Choroterpes (fig. 55). In Siphlurus (fig. 51) and Euthyplocia (fig. 59) the lacinia is covered with short hairs. Sometimes the lacinia is reduced to a slender lobe (Ameletus, fig. 61, Lc), or is absent entirely (Rhithrogena, fig. 48). Among the Heptageninae the lacinia is diminished in size. In Heptagenia it is present on the left mandible (fig. 53, Lc) and absent on the right (fig. 54). A row of hairs is often found on those forms where the lacinia is weak or absent. In Rhithrogena (fig. 48) the hairs are pectinate. These hairs are cuticular appendages, and entirely different in origin from the lacinia.

*Canines.* A generalized May-fly mandible possesses two teeth at the apex (Pl. I, fig. 12, oc, ic) known as outer and inner canine. When in position, they are more or less ventrally directed. The two canines of the right mandible of Hexagenia (Pl. II, fig. 28) dovetail between the outer and inner canine of the left mandible. The raised surface of the epipharynx fits into the anterior cavity formed by the two outer canines. This explains its position a little to the right of the center in many forms (Pl. III, fig. 34; IV, 43, 44, Ep). In the Baetinae and Ephemerinae the canines are toothed and used for tearing or holding. In the Heptageninae they are more or less scoop-shaped.

A survey of the mandibles of our North American forms confirms the systematic grouping of the three sub-families and reveals generic characters as

definite as are furnished by other organs. These are summarized in the following key:

I. MANDIBLE WITH TUSK. — *EPHEMERINAE.*

- A. Tusk shorter than mandible proper, tf.* 23. — *Potamanthus.*
- AA. Tusk longer than mandible proper.
  - (a) Tusk with spines, and out curved
    - (b) Outer edge serrated, tf. 12. — *Pentagenia.*
    - (bb) Outer edge not serrated, tf. 17. — *Ephemera.*
  - (aa) Tusk without spines
    - (b) Tusk incurved
      - (c) Outer edge serrated, tf. 24. — *Polymitarcys.*
      - (cc) Outer edge not serrated; hairs long and abundant, tf. 21. — *Euthyplocia.*
    - (bb) Tusk nearly straight, very slightly out curved at tip, tf. 14. — *Hexagenia.*

II. MANDIBLE WITHOUT TUSK.

- A. Outer canine with large teeth. — *BAETINAE.*
  - (a) Outer canine with 5 teeth, tf. 19; inner canine with 4 teeth. — *Ameletus.*
  - (aa) Outer canine with 4 large teeth.
    - (b) Inner canine with 5 teeth, tf. 18. — *Callibaetis.*
    - (bb) Inner canine with 4 teeth, tf. 22. — *Baetis.*
    - (bbb) Inner canine with 3 teeth.
      - (c) Outer edge of mandible straight, or nearly so, tf. 3. — *Siphlurus.*
      - (cc) Outer edge of mandible distinctly curved.
        - (d) Outer edge of mandible with a distinct curve from base to apex, tf. 8; lacinia bluntly cone-shaped, with short hairs at tip. — *Caenis.*
        - (dd) Outer edge of mandible with a distinct curve at the apex; lacinia with long hairs at the tip, tf. 10, 25. — *Blasturus.*
    - (bbbb) Inner canine with 2 teeth.
      - (c) Outer edge of mandible with a distinct curve near the base, and with long spines, tf. 13. — *Tricorythus.*

*tf., text figure.

II. Mandible Without Tusk—*Continued.*

(cc) Outer edge of mandible with a gentle curve midway between base and apex, and with short spines, tf. 20. *Ephemerella.*

(aaa) Outer canine with three large teeth.

(b) Inner canine with 4 teeth, tf. 15. *Chirotenetes.*

(bb) Inner canine with 3 teeth. *Choroterpes.*

(bbb) Inner canine with 2 teeth.

(c) Outer edge of mandible serrated; lacinia broad at base, and cone-shaped, tf. 1. *Baetisca.*

(cc) Outer edge of mandible not serrated; lacinia slender, tf. 2. *Leptophlebia.*

AA. Outer canine without large teeth, more or less scoop-shaped; edge crenated. *HEPTAGENINAE.*

(a) Outer canine with small teeth at apex.

(b) Outer canine, with 1 small tooth at apex, tf. 5. *Heptagenia.*

(bb) Outer canine with 2 small teeth at apex, tf. 6. *Ecdyurus.*

(aa) Outer canine without small teeth at apex; edge finely crenated.

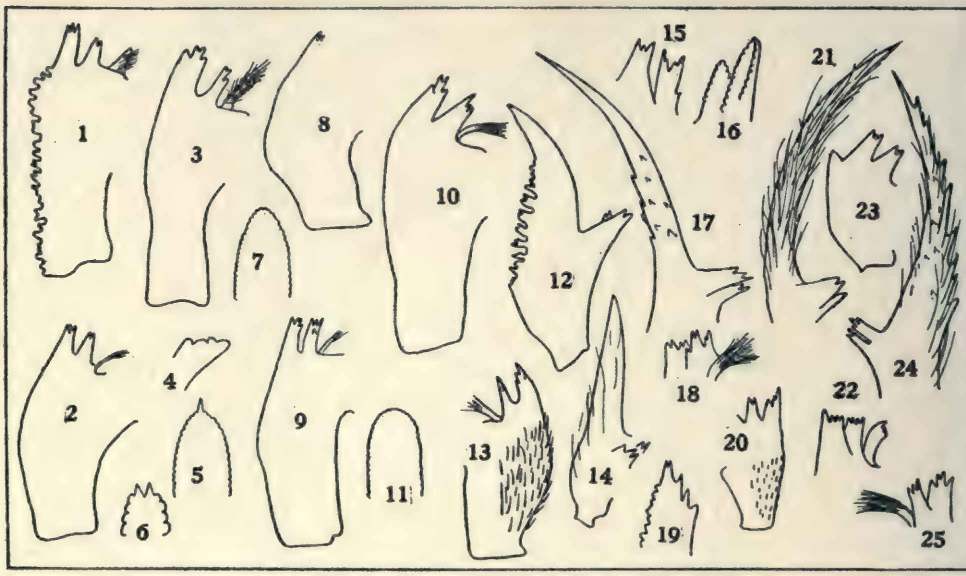
(b) Inner canine not more than ½ length of outer canine (Pl. IV, fig. 48). *Rhithrogena.*

(bb) Inner canine more than ½ length of outer canine.

(c) Inner canine but little over ½ length of outer canine; edge coarsely crenated, tf. 4; outer canine sharp at tip, tf. 7. *Epeorus.*

(cc) Inner canine almost as long as outer canine, tf. 16; edge finely crenated; outer canine blunt at apex, tf. 11. *Iron.*

TEXT-FIGURE I.




*Types of May-fly Mandible.* 1. Baetisca, molar surface removed. 2. Leptophlebia, molar surface removed. 3. Siphlurus, molar surface removed. 4. Epeorus, inner canine. 5. Heptagenia, outer canine. 6. Ecdyurus, outer canine. 7. Epeorus, outer canine. 8. Caenis, all tips removed. 9. Callibaetis, molar surface removed. 10. Blasturus, molar surface removed. 11. Iron, outer canine. 12. Pentagenia. 13. Tricorythus, molar surface removed. 14. Hexagenia, molar surface removed. 15. Chirotenetes, outer and inner canine. 16. Iron, canines. 17. Ephemera, molar surface removed. 18. Callibaetis, canines and lacinia. 19. Ameletus, outer canine. 20. Ephemerella, molar surface removed. 21. Euthyplocia, tusk and canines. 22. Baetis, canines and lacinia. 23. Potamanthus, molar surface removed. 24. Polymitarcys, molar surface removed. 25. Blasturus, canines and lacinia.

Among the exotic genera are some rather aberrant forms. In the nameless Chilean nymph figured by Eaton (Pl. IV, fig. 63, c), the canines are extremely well developed, and certainly suggest carnivorous habits. This region in Palingenia (fig. 49, c) is not distinctly differentiated. Lachlania (fig. 56, c) possesses but one canine on the mandible, and that is no longer apical in position. The canines of Homeoneuria (fig. 62) and Lachlania are covered with scale-like teeth.

## HYPOPHARYNX (Pl. V).

The hypopharynx of May-fly nymph is a relatively large tongue-like process at the dorsal base of the labium. As with the labrum, the chief variations are in the form of the anterior border. The free edge of the median lobe of Ameletus

(fig. 65, m) is straight; while that of Habrophlebia (fig. 66) is notched. In Callibaetes (fig. 67) this lobe is produced in the center. The lateral lobe (l) of Habrophlebia (fig. 66) is emarginate at the anterior border. In Polymitarcys (Pl. III, fig. 36) it is notched at the posterior border. The hairs on the outer border of both lobes of the hypopharynx are incurving, and doubtless aid in retaining food.

### Maxilla (Pl. V).

The main adaptations to environment in the nymphal maxilla involve loss of segmentation, and peculiar cuticular appendages.

Reduction in segmentation in the body of the maxilla is primarily a consolidation for strength. Galea and lacinia are fused, although in some forms, as Hagenulus, (fig. 85) faint traces of the suture remain. The articulation between the stipes (St) and galea-lacinia (Ga-Lc) is differentiated in Lachlania (fig. 83), but in most cases indistinctly (Hagenulus fig. 85; Hexagenia fig. 77; Blasturus fig. 75), or not at all (Baetisca fig. 78). The palpifer also shows gradations in fusion. That of Blasturus (fig. 75, Plf) or Rhithrogena (fig. 69) is well defined. In Hagenulus (fig. 85) or Hexagenia (fig. 77) it is not so clearly differentiated. The cardo is distinct.

Reduction in segmentation in the maxillary palp takes place by fusion, by incomplete differentiation, and by loss of segments. Where there is consolidation, the parts are heavily chitinized. This condition is found in the first segment of the palp in Lachlania (fig. 83). It is fused proximally with the palpifer. There is incomplete differentiation of the distal segment in some forms. In these (Blasturus fig. 75; Hagenulus fig. 85; Hexagenia fig. 77) the chitinization is weak. Entire loss of segmentation is found in *Ephemerella deficiens* Morgan (fig. 82), where there is no palp at all. Members of this genus are found in streams with gravel bottoms. The mouth-parts are small, retracted, and heavily chitinized. Loss of the palp is the extreme of specialization in this line.

The reduced multiarticulate palp (fig. 68, 72) of the nameless Chilean nymph figured by Eaton is an aberrant form.

The cuticular appendages of the maxilla mainly consist of bristles, rakers and heavy spines. Bristles are best developed in those forms among the Baetinae that inhabit swift water. They serve as diatom brushes and plancton strainers (Hagenulus fig. 85). This is a specialization for food getting which parallels the labial diatom rakers of the Heptageninae. On the ventral surface of the blade-like distal palp segment of one of these (Rhithrogena, fig. 69) are countless numbers of tiny toothed spines (fig. 70). Mixed with these combs at regular intervals are crook-shaped hairs. Spines are present on the galea-lacinia of those forms of the Baetinae that dwell in rocky streams (Ephemerella fig. 82; Baetisca fig. 78). The greatest development in this line is the teeth-like spines on Eaton's nameless Chilean nymph (fig. 68).

Tracheal gills (G) are present on the maxilla of Lachlania (fig. 83) and some other swift water forms.

### Labium (Pl. V).

Since the primary function of the labium is to prevent the escape of food, and to sweep it into the pharyngeal cavity, the main adaptations are found in the ligular region. The greatest changes in this region are found among the Baetinae dwelling in swift water. There are two lines of specialization. In the one are forms with reduced mouth-parts. The glossa (gl) and paraglossa (Pgl) lose their segmentation in part as in Ephemerella (fig. 71) or entirely as in Tricorythus (fig. 64). In the other line of specialization are forms with the mouth-parts more or less enlarged and depressed. The ligula is expanded and constitutes the greater part of the body of the labium. The glossa of Lachlania (fig. 76) is not differentiated from the ligula. The paraglossae (Pgl) are enlarged and produced anteriorly until their tips are contiguous. The whole labium resembles a scoop. The same result is obtained among the Heptageninae, but by a different specialization. There, as in Lachlania, the ligula (fig. 84, Lg) forms the main bulk of the labium; but the glossa and paraglossa, though small, are distinct. It is the basal portion of the ligula that is expanded.

The main adaptations in the labial palp involve reduction in segmentation, or decrease in size. In those swift water forms that have mouth-parts depressed and the palp flattened and blade-like, there may be a consolidation of segments. This condition is found in Epeorus (fig. 84). The second palp segment is small, heavily chitinized, and incapable of independent movement. No musculature is developed for this segment. The palp of Oligoneuria (fig. 76) is two-segmented. In those swift water forms where the head is small and the mouth-parts retracted, there is a reduction in the size of the entire palp, particularly the distal part. The second and third segments of the palp of Tricorythus (fig. 64) are very reduced, and weakly chitinized. In *Baetis sp.* (fig. 73), the distal portion of the second palp segment is enlarged and bears an inner prolongation. The third segment is knob-like and fits down into the enlarged tip. It is weakly chitinized and the articulation is incompletely differentiated. Specimens of this genus which do not inhabit rocky places in swift water show a less knobbed distal segment, and better differentiated articulation. Greater specialization in this line is found in the labial palp of *Baetisca obesa* (fig. 74). There the inner prolongation of the second segment is longer and tooth-like. The third segment is small and pointed, giving a forceps-like appearance. However, this segment is weakly chitinized and shows no musculature.

The cuticular appendages of the labrum are similar to those of the maxilla of the same forms. *Baetisca obesa* (fig. 74) has chitinized papillae on the ligula and submentum.

The labial palp of Eaton's nameless Chilean nymph (fig. 80) is multiarticulate. The addition appears to result from secondary division of the distal segment.

# VI—MOUTH PARTS OF THE SUBIMAGO AND IMAGO

May-fly mouth-parts are vestigial during the life of the subimago and imago. External evidences of degeneration are shown in reduced size, asymmetrical form, and general lack of chitinization. Internally there is a degeneration of the musculature.

## EXTERNAL METAMORPHOSIS.

A comparison of the functional mouth-parts of a Hexagenia nymph (Pl. III, fig. 34) with the atrophied mouth-parts of the subimago of the same species (Pl. VI, fig. 98) shows the change of form with loss of function. Molar surface, canines, and lacinia of the mandible (Md) are not differentiated. The large chitinized tusk (Pl. II, fig. 26, T) is soft, irregular and thread-like (Pl. VI, fig. 98, T). The maxillae (Mx) show no segmentation, although the labium (Lb) does contain traces of a suture between the mentum and submentum. The labrum is visible only after dissection. It is a tiny misshapen protuberance retracted beneath the nose-like clypeus (Clp). A shapeless papilla drawn back into the pharyngeal opening is the only remnant of the hypopharynx. There are no hairs or spines. All the mouth-parts are diminished in size, irregular in form, and very weakly chitinized.

Atrophy of the mouth-parts is progressive during the aerial life of an individual (Compare figs. 88, 90, 93, with figs. 95, 96, and 97). It also varies in extent among members of a species. (Compare figs. 88, 89, 90; 91, 92; 93, 94).

## INTERNAL METAMORPHOSIS.

Internal evidence of the metamorphosis of Ephemerine mouth-parts is shown in the degeneration of the musculature. In the mouth-parts proper there is a gradual regressive process during aerial life.* The part of the head capsule occupied during nymphal life by the strong mandibular adductors, is filled by the large compound eyes after transformation. Although these eyes have been developing internally since mid nymphal life, they attain the greater part of their enormous size just at transformation. Specimens observed to feed one-half hour before emergence show no traces of mandibular adductors one hour later. There are, then, two physiological types of degeneration: a simple progressive atrophy of the mouth-parts proper; and a rapid degeneration of the mandibular adductors. Histologically degeneration is the same in both cases.

---

*Specimens of *Hexagenia recurvata* emerged in mid-afternoon May 31; spent two days as subimago; mated at sundown two days later, and died that evening.

Normal Muscle. A nomal muscle of the mouth-parts in longitudinal section shows the dark bands relatively broad and deep blue staining. The light bands are narrow, with Krause's membrane showing as a distinct dark line. The nuclei are oval and lie just under the sarcolemma. Their chromatin is coarse, dark purple staining, and lies chiefly about the periphery. In cross section Cohnheim's areas are evident.

Plasma Cells. In the body plasm from the first instar through imaginal life there are five varieties of cells (Pl. VI, fig. 87), which intergrade with no sharp lines of demarcation:

A. Little cells with a small amount of deep-blue staining, homogeneous cytoplasm; nuclear chromatin evenly distributed, deep-purple staining, and coarsely reticular. These cells show very slight ameboid movement.

B. Cells 1.5 to 3 times the size of variety A, with a large amount of homogeneous cytoplasm varying from dark to light blue; nuclear chromatin deep-purple staining, coarsely reticular and evenly distributed. These cells show mitotic division and active ameboid movement.

C. Cells 2 to 3 times the size of variety A; with light blue staining vacuolated cytoplasm; nuclear chromatin finely reticular and light-purple to dark-blue staining. Spindle forms are common. Ameboid movement is active.

D. Cells 2 to 3 times the size of variety A; with small pink staining areas or a few pink granules; cytoplasm light blue staining and vacuolated, similar to variety C. Spindle forms are common. Ameboid movement is active.

E. Cells 1 to 4 times the size of variety A; with many deep-pink staining granules; cytoplasm staining a very light reticular blue, or not at all; nucleus light purple, with coarsely reticular chromatin, and light staining ground substance.

Smears made from the abdominal cavity of the nymph and subimago just after molting show many degenerating plasma cells. The most common form is vacuolated, with the nucleus crowded to the periphery (fig. 87, w). Some of the vacuoles contain pink granules or diffuse pink areas.

Degenerating Muscle. Not all the muscles of the mouth-parts degenerate simultaneously; neither is an entire muscle at the same stage of degeneration. This process is evident in portions of some of the mouth-part muscles of *Hexagenia recurvata* five days before emergence. In all the specimens examined cross-striations were visible in portions of the muscle just before transformation.

Early in degeneration the dark bands stain lighter and irregularly (Pl. VI, fig. 86, I). The light bands increase in width, and Krause's membrane is no longer evident. The muscle nuclei (n) are swollen and stain faintly. There is also slight evidence of fibrillation. Then the muscle substance changes from blue to

pink in color, and the cell contents (II), begin to liquify. The nuclei (n) assume a spherical shape and their chromatin becomes diffuse. Plasma cells of the five varieties (A, B, C, D, E) increase in the proximity of the degenerating muscle. In cross section (IV) Cohnheim's areas are not evident, and many of the fibers are vacuolated. As degeneration increases, the dark bands disappear (III) and the muscle substance stains more and more faintly. The sarcolemma is no longer evident, and the nuclei (n) rupture. Finally nothing remains but a formless mass (V), and that soon ceases to stain. There is no evidence of phagocytosis.

During the muscle degeneration no plasma cells are present that do not occur in a first instar nymph. The following differential count from smears of the plasma of nymph, subimago and imago shows a proportional increase in varieties D and E after transformation, and a decrease in varieties A and B.

* % of Plasma Cells in Differential Count.

| Variety | Nymph | Subimago | Imago |
|---|---|---|---|
| A | 25.0 | 1.3 | 1.5 |
| B | 12.5 | 2.3 | 1.5 |
| C | 27.5 | 16.7 | 22.0 |
| D | 5.0 | 11.7 | 26.0 |
| E | 30.0 | 68. | 49.0 |

Tracheae (Pl. VI, fig. 86, Tr.) and tracheoles (tr) persist after the muscles have entirely lost their identity. These cells have a finely granular dark purple staining cytoplasm, and a densely staining finely reticular nucleus.

## DISCUSSION.

The nature of the cells present in the vicinity of metamorphosing muscles among holometabolic insects has long been a subject of discussion. Berlese and Terre contend that the cells are not leucocytes, but are developed from the nuclei of the larval muscles; Anglas and Perez, that they do not arise from the nuclei of larval muscles, but are leucocytes. Deegner says that spindle-shaped cells whose origin is uncertain, appear in the late larva of Hydrophilus. Breed, 1913, in a very complete work on the metamorphosis of the muscles of a beetle writes: "Mesenchymal cells arise singly from the tracheae or hypodermis, and give rise to tracheae, leucocytes, and other related tissues (p. 353)—It is probable that some of these tracheal cells become leucocytes—Certainly the large vacuolated leucocytes which have persisted from the larva, disappear in old pupae, and their

*100% = 500 plasma cells.

places are taken by smaller less vacuolated cells. These new leucocytes grow in size and soon are characteristically vacuolated (p. 355)."

That the same cells may appear very unlike with different fixers is possible. None of the authors quoted have used a technique which permits a direct comparison of plasma cells in section and in smear.

In the metamorphosis of the muscles of May-fly mouth-parts, I find no evidence of a proliferation of free tracheal cells. There is a rapid increase in tracheal cells just after the various nymphal molts, but they form tracheoles. The varieties of plasma cells in the vicinity of the degenerating muscles are the same as those found in the first instar nymph. The muscle nuclei clearly degenerate. There is no evidence of phagocytosis.

# VII—BIBLIOGRAPHY

ANGLAS, J. 1899. Sur l'histogénèse des muscles imaginaux des Hyménoptères. Comp. Rend. et Mém. Soc. Biol., Paris, (I) 51:947-949.

ANGLAS, J. 1900. Sur la signification des termes "phagocytose" et "lyocytose." Comp. Rend. et Mém. Soc. Biol., Paris, (II) 52:219-221.

ANGLAS, J. 1901. Quelques caractères essentiels de l'histolyse pendant la métamorphose. Bull. Soc. Ent. France, Année, 1901, pp. 301-304.

BAUER, A. 1910. Die Muskulatur von Dytiscus marginalis, Marburg.

BERLESE, A. 1900. Intorno alle modificazioni de alcuni tessuti durante la ninfosi della Calliphora erythrocephala. Bull. Soc. Ent. Ital., Anno 32, pp. 253-288, 7 fig.

BERLESE, A. 1900. Considerazioni sulla Fagocitosi negli insetti metabiolici. Zool. Anz., 23:441-449.

BERLESE, A. 1902. Osservazioni au fenomeni che avvengono durante la ninfosi degli insetti metabolici. Parte II. Tessuto musculare. Revista Patolog. Vegetale, Anno 10, pp 1-120, tav. 11-14, 4 fig.

BERLESE, A. 1909. Gli Insetti. Milano.

BORNER, C. 1909. Neue Homologien zwischen Crustacean und Hexapoden. Die Beiss mandibel der Insekten und ihre phylogenetische Bedeutung. Archi-und-Metapterygota. Zool. Anz., 34:100-125.

BREED, R. S. 1903. The Changes which Occur in the Muscles of a Beetle, *Thymalus marginicollis* Chevr., during Metamorphosis. Bull. Mus. of Comp. Zool., Harvard College, Vol. 40, No. 7.

BURMEISTER, H. 1832. Handbuch der Entomologie. Berlin.

BURMEISTER, H. 1848. Beitrag zur Entwicklungsgeschichte der Ephemeren. Zeitung für Zoologie, Zootomie, und Palaezoologie herausgegeben Von E. D. Alton and H. Burmeister, Nr. 14, Bd. 1, s. 109-112, Taf. 1, Fig. 20-24.

CLEMENS, W. A. 1913. New Species and New Life Histories of Ephemeridae or May-flies. Canad. Ent., 45:246-262.

CLEMENS, W. A. 1915. May-flies of the Siphlonurus Group. Canad. Ent., 47:247-260.

CLEMENS, W. A. 1917. An Ecological Study of the May-fly *Chirotenctes albomanicatus* Needham. Univ. Toronto Studies, Biol. Ser. 17.

COMSTOCK, J. H., and KOCHI, C. 1902. The Skeleton of the Head of Insects. Amer. Nat., 36:13-45.

CUENOT, L. 1895. Etudes physiologiques sur les Orthoptérès. Arch. Biol., 14:293-341, pls. 12, 13.

## BIBLIOGRAPHY.


CUENOT, L. 1899. Les pre'tendus organes phagocytaires decrits par koulvetch chez la Blatta. Arch. Zool. Exp., 1899, pp. 1, 2.

DEEGNER, P. 1900. Entwicklung der Mundwerkzeuge und des Darmkanals von Hydrophilus. Zeit. f. wiss. Zool., 68:113-168. Taf. 8-10.

DRENKELFORT, HEINRICH. 1910. Neue Beitrage zur Kenntnis der Biologie und Anatomie von Siphlurus lacustris Eaton. Münster.

EATON, A. E. 1883. A Revisional Monograph of Recent Ephemeridae. Pt. I., London Trans. Soc., 3:1-77, pls. I-XXIV.

EATON, A. E. 1884. A Revisional Monograph of Recent Ephemeridae. Pt. II., 3:78-153, pls. 25-45.

EATON, A. E. 1885. A Revisional Monograph of Recent Ephemeridae. Pts. III and IV., London Trans. Linn. Soc., 3:153-281, pls. 46-63.

EATON, A. E. 1887. A Revisional Monograph of Recent Ephemeridae. Pt. V., London Trans. Linn. Soc., 3:281-319, pls. 64-65.

FOLSOM, J. W. 1900. Mouth-Parts of Anurida maritima Guer. Bull. Mus. Comp. Zool., Vol. 36, No. 5.

HAGEN, H. 1849. Uebersicht der neueren Literatur betreffenend die Neuroptera Linne. Stettiner Ent. Ztg., 10:353-371.

HAGEN, H. 1873. Report on the Pseudoneuroptera and Neuroptera of North America in the collection of the late Th. W. Harris. Boston, Mass. Proc. Soc. Nat. Hist., 15:263-301.

HAGEN, H. 1873. Compiled by Eaton. Notes on the Ephemeridae. London, Trans. & Proc. Ent. Soc., 381-406.

HAGEN, H. 1888. Unsere gegenwärtige Kentniss der Ephemeren. Stettiner Ent. Ztg. Juli Sept., 49:221-232.

HEYMONS, R. 1895. Die Segmentirung des Insection Körperes. Anh. z. d. Abhandl. Königl. preuss. Akad. Wien, p. 39, 1 pl.

HEYMONS, R. 1896. Grundzuge der Entwicklung und der Korperbaues von Odonaten und Ephemeriden. Abhandl. der Kgl. pruess. Akademie d. Wisessensch. zu Berlin, pp. 17-26, pl. 2.

HEYMONS, R. 1896. Ueber die Lebensweise und Entwicklung von Ephemera vulgata L. Sitzungsb. Gesell. Naturf. Freunde, Berlin, pp. 81-96.

HOLLANDE, A. CH. 1909. Contribution a l'etude du sang des Coleoptéres. Arch. Zool. Paris (5), 2:271-299.

JOLY, N. 1871. Sur l'hypermetamorphose de la Palingenia virgo a l'etat du larvae; analogies de cette larve avec les Crustaces. Mem. Soc. Toulouse (7), 3:379-386; Ann. Aci. Nat. Paris (5), 15:1-5.

JOLY, N. 1876. Etudes sur l'embrogenie des Ephemeres, Notammant chez la Palingenia virgo. Mem. Ac. Toulouse. Comp. Rend., 82:1030-1034, and Ann. Mag. Nat. Hist. London (4), 17:481-484.

KOROTNEFF, A. 1892. Histolyse und Histogenese der Muskelgewebes bei der Metamorphose der Insekten. Biol. Centralbl., 12:261-265, 5 text fig.

## BIBLIOGRAPHY.


LESTAGE, J. A. 1917. Contribution a l'etude des Larves des Ephemeres Palearctiques. Extrait des Ann. de Biol. lacustre. Tome VIII.

LUBBOCK, J. 1866. On the Development of Chloeon dimidiatum. Trans. Linn. Soc., 24:61-78; 25:477-492.

MERCEF, W. F. 1900. The Development of the Wings in the Lepidoptera. Journ. N. Y. Ent. Soc., 8:1-20.

MIALL, L. C. and HAMMOND, A. R. 1900. The Structure and Life History of the Harlequin Fly, pp. 77-79, Oxford.

MORGAN, A. H. 1911. May-flies of Fall Creek. Ann. Ent. Soc. Am., 4:93-114.

MORGAN, A. H. 1913. A Contribution to the Biology of May-flies. Ann. Ent. Soc. Amer. (3), 6:371-413, pls. XLII-LIV.

NEEDHAM, J. G. and BETTEN, C. 1901. Aquatic Insects in the Adirondacks. N. Y. State Mus., Bull. 47.

NEEDHAM, J. G. 1903. Aquatic Insects of New York State. N. Y. State Mus., Bull. 68.

NEEDHAM, J. G. 1905. May-flies and Midges of New York. N. Y. State Mus., Bull. 86.

NEEDHAM, J. G. 1909. Notes on the Neuroptera in the Collection of the Indian Museum. Ind. Mus. Rec. (3), 12:191-192.

NEEDHAM, J. G. and LLOYD, J. T. 1916. Life of Inland Waters. Ithaca, N. Y.

NEEDHAM, J. G. 1918. Fresh Water Biology. Ward, H. B. and Whipple, G. C., pp. 876-946, New York and London.

PATTEN, W. 1884. The Development of Phryganids with a Preliminary Note on the Development of Blatta germanica. Quar. Journ. Microsc. Sci., 24:549-602.

PEREZ, C. 1899. Sur la métamorphose des Insectes. Bull. Soc. Entomol. France; Annee 1899, pp. 398-402.

PEREZ, C. 1900. Sur l'histolyse musculaire chez les insectes. Comp. Rend. et Mem. Soc. Biol. Paris (1), 52:7-8.

PICTET, T. J. 1843. Histoire naturelle generale et particuliere des Insectes Neuropteres. Geneve, Ressman.

RILEY, W. A. 1904. Embryological Development of the Skeleton of the Head of Blatta. Amer. Nat., 38:777-810.

STERNFELD, R. 1907. Die Verkümmerung der Mundteile und der Funktionswechsel des Darms bei den Ephemeriden. Zool. Jahrb., Jena. Abt. fur Anat. & Ont., 24:415-430.

STRAUS-DURKEHEIM, H. E. 1828. Considerations generales sur l'anatomie comparee de Animaux de Animaus Articules, aux quelles on a point 'l anatomie descriptive du hanneton vulgaire. Paris.

SWAMMERDAM, J. 1758. The Book of Nature or the History of Insects.

TERRE, L. 1899. Contribution a l'étude de l'histolyse et l'histogénèse des tissus musculaire chez l'Abeille. Comp. Rend. et Mém. Soc. Biol. Paris (11), 51:896-898. Also in Bull. Soc. Entomol. France, Annee 1899, pp. 351, 352.

## BIBLIOGRAPHY.


TERRE, L. 1900. Sur l'histolyse musculaire des Hyménopterès. Comp. Rend. et Mém. Soc. Biol. Paris (11), 52:91-93. Also in Bull. Soc. Entomol. France, Annee 1900, pp. 23-25.

TERRE, L. 1900. Métamorphose et phagocytose. Comp. Rend. et Mém. Soc. Biol. Paris (11), 52:158-159.

VAYSSIERE, A. 1882. Recherches sur l'organization des Larves des Ephemerines. Ann. Sci. Nat. (6), 13:1-137, pls. 1-10.

WEISMANN, A. 1866. Die Metamorphose der Corethra plumicornis. Zeit. f. wiss. Zool., 16:45-132, Taf. 3-7.

WHEELER, W. M. 1889. Embryology of Blatta germanica and Doryphora decemlineata. Journ. Morph., 3:291-386.

WHEELER, W. M. 1892. Concerning the Blood Tissue of the Insects. Psyche, 6:216-220; 233-256, pl. 7.

WIELOWIEZSKI, H. 1886. Ueber das Blutgeweben der Insekten. Zeit. f. w. Zool., 43:512-530.

√ WOLTER, M. 1883. Die Mundbildung der Orthopteren mit specieller Berucksichtigung der Ephemeriden. Greifswald.

# EXPLANATION OF PLATES

Unless otherwise stated, the figures are original and made with the aid of the camera lucida.

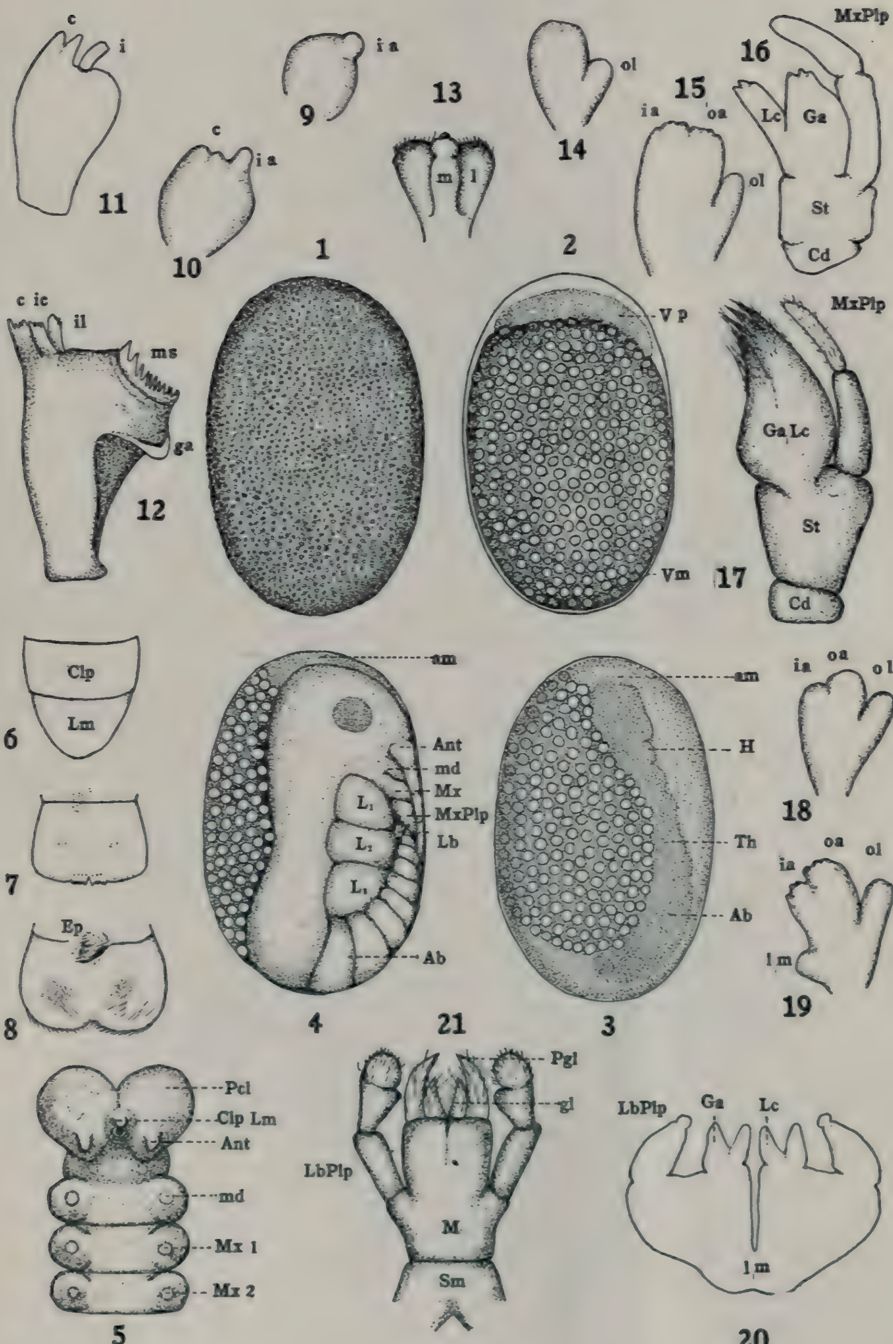
## ABBREVIATIONS

A—variety of plasma cell
Ab—abdomen
Abd—abductor
ad—adductor
am—amnion
Ant—antenna
ap—apodeme
B—variety of plasma cell
C—variety of plasma cell
c—canine
Cd—cardo
c.h.—Cohnheim's area
Clp—clypeus
co—compressor
D—variety of plasma cell
d—depressor
E—variety of plasma cell
e—extensor of palp
El—elevator
Ep—epipharynx
ep—epipharyngeal muscle
F—fat
f—flexor of palp
Fl—flexor.
Ga—galea
ga—ginglymous articulation
Ga Lc—galea-lacinia
gl—glossa
H—head
ia—inner apical region
ic—inner canine
il—inner lobe
L—leg
l—lateral lobe
Lb—labium
Lb Plp—labial palp
Lc—lacinia
Lg—ligula
lm—lower median region
M—mentum
m—median lobe
md—mandible
m s—molar surface
Mx—maxilla
Mx Plp—maxillary palp
n—nucleus
oa—outer apical region
oc—outer canine
ol—outer lateral region
Pcl—procephalic lobe
Pgl.—paraglossa
Plf—palpifer
Plg—palpiger
R—retractor
St—stipes
T—tusk
Th—thorax
Tn—tentorium
Tr—trachea
tr—tracheole
Vm—vitelline membrane
Vp—ventral plate
I, II, III, IV, V—degenerating muscle

PLATE I

Fig. 1. Egg of *Baetis posticatus.*
Fig. 2. Embryo, 2 days.
Fig. 3. Embryo, 4 days.
Fig. 4. Embryo, 9 days.
Fig. 5. Head region, embryo, 5 days.
Fig. 6. Clypeo-labrum, 8 days.
Fig. 7. Labrum, 10 days, ventral aspect.
Fig. 8. Labrum, 11 days, ventral aspect.
Fig. 9. Right mandible, 6½ days.
Fig. 10. Right mandible, 7½ days.
Fig. 11. Right mandible, 9 days.
Fig. 12. Left mandible, 11 days.
Fig. 13. Hypopharynx, 11 days.
Fig. 14. Left 1st maxilla, 6 days.
Fig. 15. Left 1st maxilla, 6½ days.
Fig. 16. Left 1st maxilla, 8 days.
Fig. 17. Left 1st maxilla, 11 days.
Fig. 18. Left 2nd maxilla, 6½ days.
Fig. 19. Left 2nd maxilla, 7 days.
Fig. 20. Labium, 9 days.
Fig. 21. Labium, 11 days.

PLATE I



c
i
11
i a
9
13
ol
14
MxPlp
16
15
ia
oa
Lc
Ga
c
i a
m
l
ol
St
10
1
2
Cd
c ic
il
ms
ga
12
V p
Vm
MxPlp
Ga Lc
St
17
Cd
Clp
Lm
6
7
Ep
8
am
Ant
md
Mx
MxPlp
Lb
Ab
$L_1$
$L_2$
$L_3$
4
am
H
Th
Ab
3
ia
oa
o l
18
ia
oa
ol
lm
19
21
Pcl
Clp Lm
Ant
md
Mx 1
Mx 2
5
Pgl
gl
LbPlp
M
Sm
LbPlp
Ga
Lc
lm
20

## PLATE II

Fig. 22. Nymph, *Epeorus humeralis.*

Fig. 23. Nymph, *Hexagenia bilineata.*

Fig. 24. Nymph, *Baetis posticatus.*

Fig. 25. Diagram of portion of postgena, Hexagenia nymph.

Fig. 26. Right mandible, Hexagenia nymph.

Fig. 27. Diagram of cross-section of ginglymous articulation of mandible, Hexagenia nymph.

Fig. 28. Diagram of body of right and left mandible of Hexagenia nymph, dorsal aspect.

Fig. 29. Diagram of right molar surface, Ephemerella nymph.

Fig. 30. Diagram of left molar surface, Ephemerella nymph.

Fig. 31. Diagram of left molar surface, Ephemera nymph.

Fig. 32. Diagram of right molar surface, Ephemera nymph.

Fig. 33. Diagram of cross-section of righ molar surface, Ameletus nymph.

PLATE II

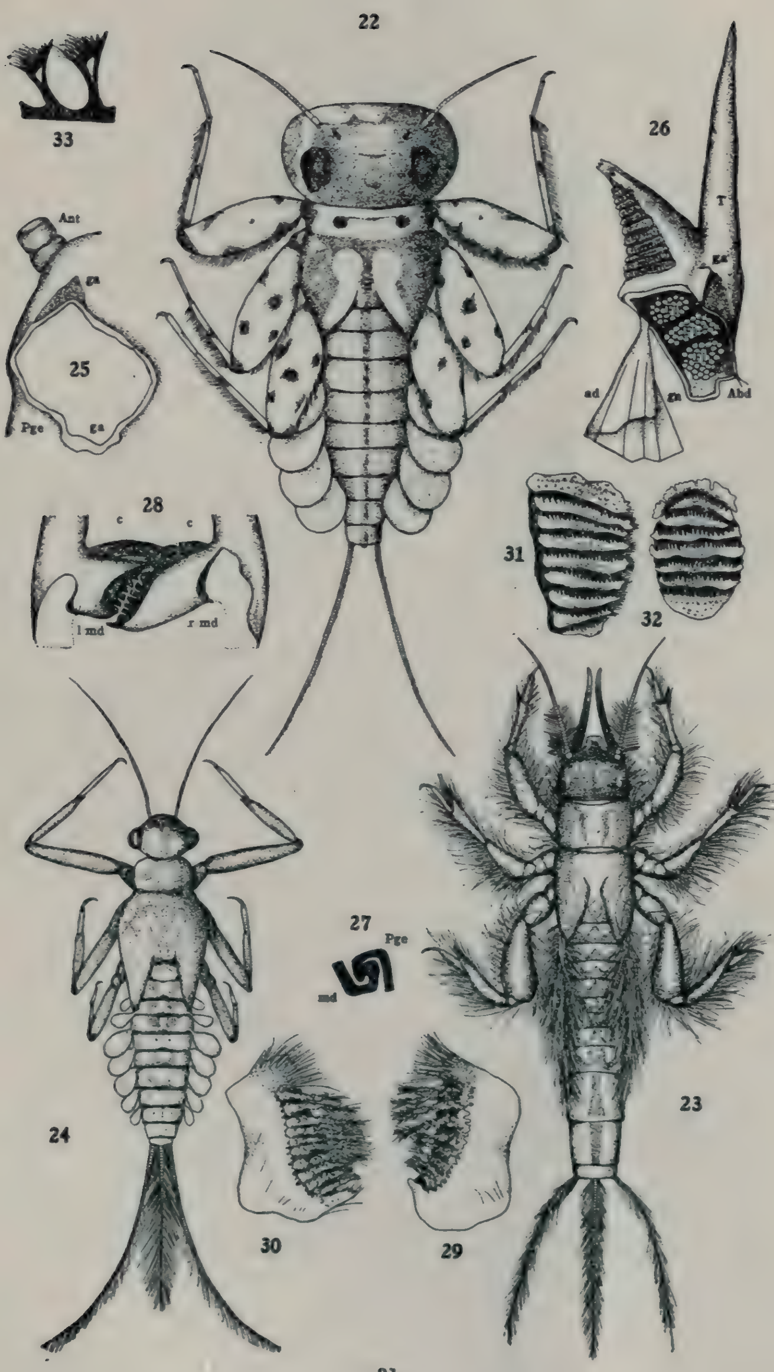

22
33
26
T
ga
Ant
ga
25
Pge
ga
ad
ga
Abd
28
c
c
l md
r md
31
32
27
Pge
md
24
23
30
29

PLATE III

Fig. 34. Diagram of ventral aspect of head of Hexagenia nymph, portion of left side removed.

Fig. 35. Diagram of labrum, Ephemerella.

Fig. 36. Diagram of hypopharynx, Polymitarcys.

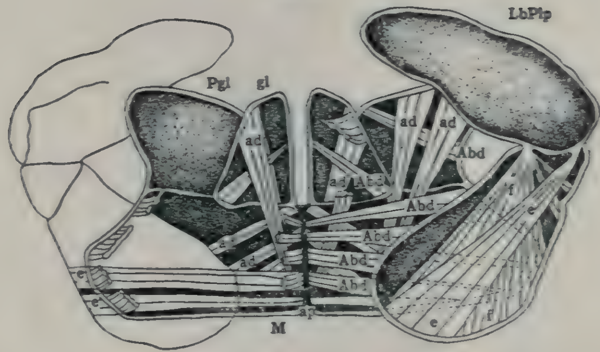
Fig. 37. Diagram of hypopharynx, Ecdyurus.

Fig. 38. Diagram of right maxilla, Ecdyurus.

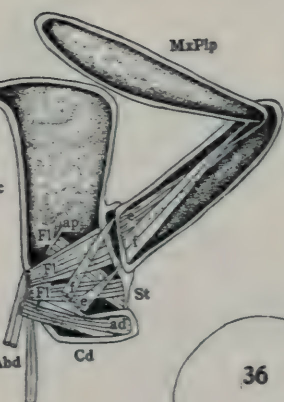
Fig. 39. Diagram of right half of labium, Ephemerella.

Fig. 40. Diagram of labium, Ecdyurus.

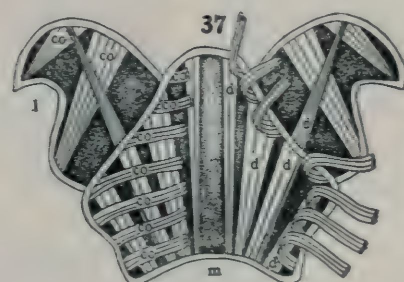
40




38

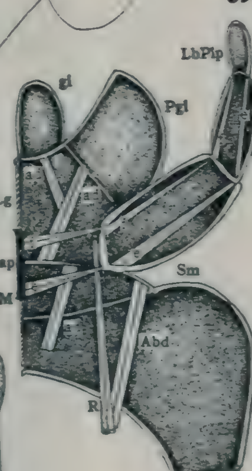


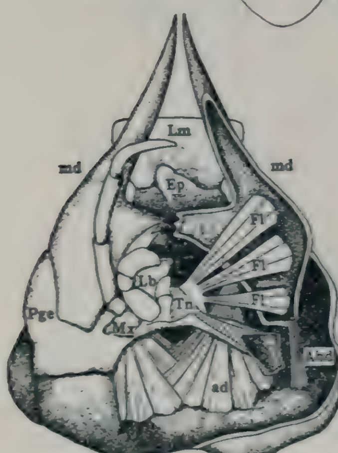

37




36

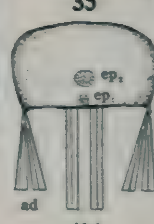

39




34

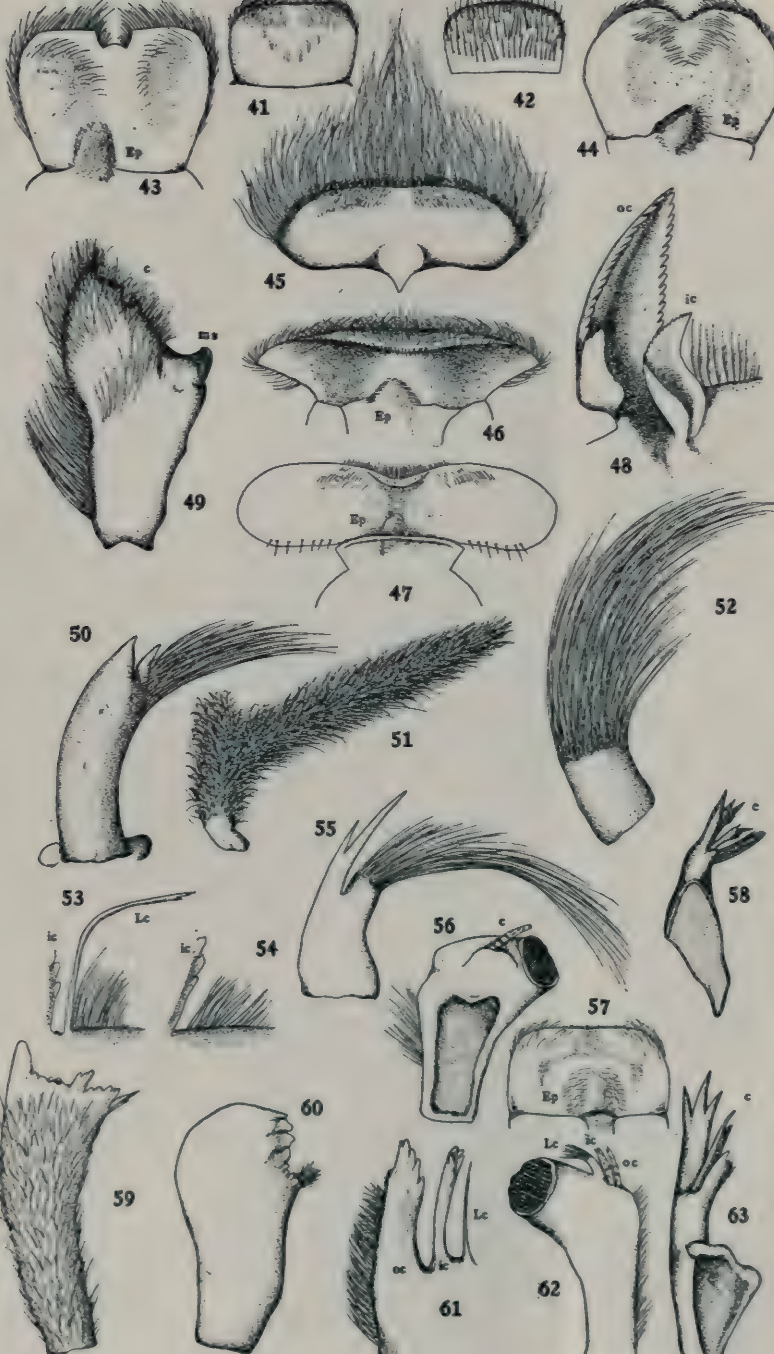
35



## PLATE IV

Fig. 41. Labrum, Polymitarcys, dorsal aspect.
Fig. 42. Labrum, Chirotenetes, dorsal aspect.
Fig. 43. Labrum, Callibaetis, ventral aspect.
Fig. 44. Labrum, Baetis, ventral aspect.
Fig. 45. Labrum, Oligoneuria, dorsal aspect.
Fig. 46. Labrum, Ecdyurus, ventral aspect.
Fig. 47. Labrum, Hagenulus, ventral aspect.
Fig. 48. Canines, Rhithrogena.
Fig. 49. Right mandible Palingenia, after Eaton.
Fig. 50. Lacinia, mandible Polymitarcys.
Fig. 51. Lacinia, mandible Siphlurus.
Fig. 52. Lacinia, mandible Leptophyes.
Fig. 53. Lacinia, left mandible Heptagenia.
Fig. 54. Lacinial region, right mandible Heptagenia.
Fig. 55. Lacinia, mandible Choroterpes.
Fig. 56. Right mandible, Lachlania.
Fig. 57. Labrum Ephemerella, ventral aspect.
Fig. 58. Right mandible Prosopistoma, after Eaton.
Fig. 59. Lacinia, mandible Euthyplocia.
Fig. 60. Lacinia, mandible Baetis.
Fig. 61. Apex right mandible, Ameletus.
Fig. 62. Left mandible, Homeoneuria.
Fig. 63. Left mandible, nameless Chilean nymph, after Eaton.

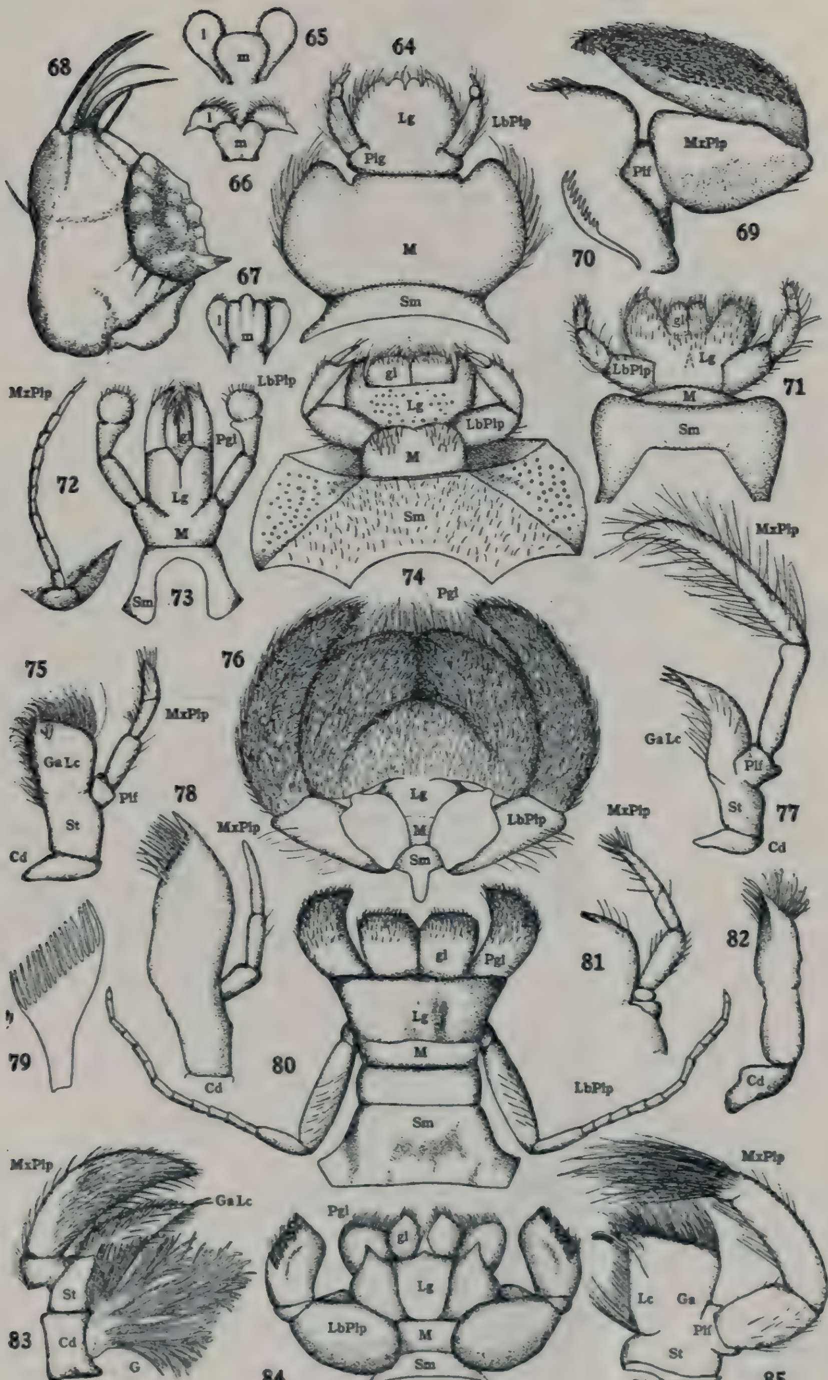
# PLATE IV


41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
Ep
c
ms
oc
ic
Lc

## PLATE V

Fig. 64. Labium Tricorythus, ventral aspect.
Fig. 65. Hypopharynx, Ameletus.
Fig. 66. Hypopharynx, Habrophlebia.
Fig. 67. Hypopharynx, Callibaetis.
Fig. 68. Right maxilla, nameless Chilean nymph, after Eaton.
Fig. 69. Left maxilla Rhithrogena, in part.
Fig. 70. Diatom raker from maxillary palp, Rhithrogena.
Fig. 71. Labium of Ephemerella, ventral aspect.
Fig. 72. Maxillary palp, nameless Chilean nymph, after Eaton.
Fig. 73. Labium Baetis, ventral aspect.
Fig. 74. Labium Baetisca, ventral aspect.
Fig. 75. Left maxilla Blasturus, ventral aspect.
Fig. 76. Labium Oligoneuria, ventral aspect.
Fig. 77. Left maxilla Hexagenia, ventral aspect.
Fig. 78. Left maxilla Baetisca, ventral aspect.
Fig. 79. Diatom raker, maxilla Rhithrogena.
Fig. 80. Labium, nameless Chilean nymph, after Eaton.
Fig. 81. Left maxilla Caenis in part, ventral aspect.
Fig. 82. Left maxilla *Ephemerella deficiens,* ventral aspect.
Fig. 83. Right maxilla Lachlania, ventral aspect.
Fig. 84. Labium Epeorus, ventral aspect.
Fig. 85. Left maxilla Hagenulus, ventral aspect.

PLATE V


68
65
l
m
l
m
66
64
Lg
LbPlp
Plg
M
Sm
67
l
m
69
MxPlp
Plf
70
71
gl
Lg
LbPlp
M
Sm
MxPlp
72
LbPlp
gl
Pgl
Lg
M
Sm
73
gl
Lg
LbPlp
M
Sm
74
Pgl
75
MxPlp
GaLc
Plf
St
Cd
76
Lg
M
Sm
LbPlp
MxPlp
GaLc
Plf
St
77
Cd
78
MxPlp
MxPlp
79
Cd
80
gl
Pgl
Lg
M
Sm
LbPlp
81
82
Cd
MxPlp
GaLc
St
83
Cd
G
Pgl
gl
Lg
LbPlp
M
Sm
84
MxPlp
Lc
Ga
Plf
St
Cd
85

## PLATE VI

Fig. 86. Muscle degeneration Hexagenia subimago of 24 hours, cross-section from mandible.

Fig. 87. Plasma cells from smear.

Fig. 88. Mandibles, subimago *Hexagenia recurvata.*

Fig. 89. Mandibles, subimago *Hexagenia recurvata.*

Fig. 90. Mandibles, subimago *Hexagenia recurvata.*

Fig. 91. Maxillae, subimago *Hexagenia recurvata.*

Fig. 92. Maxillae, subimago *Hexagenia recurvata.*

Fig. 93. Labium, subimago *Hexagenia recurvata.*

Fig. 94. Labium, subimago *Hexagenia recurvata.*

Fig. 95. Labium, imago *Hexagenia recurvata.*

Fig. 96. Labium, imago *Hexagenia recurvata.*

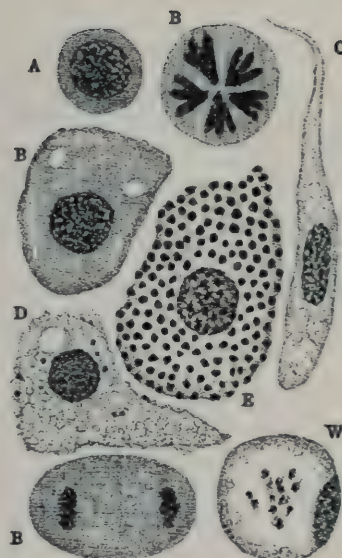
Fig. 97. Mandibles, imago *Hexagenia recurvata.*

Fig. 98. Head, subimago *Hexagenia recurvata,* ventral aspect.

# PLATE V I

86

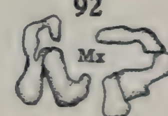

87

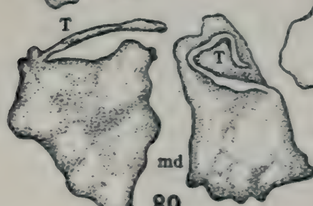



91


88


92



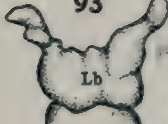



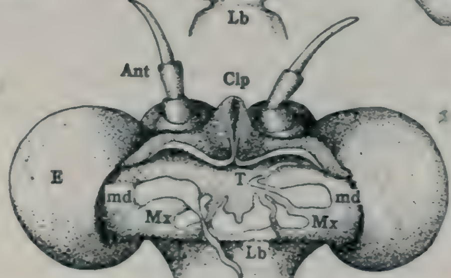

89

90


95


93




94



96

98


97

# II—Notes on the Biology of Mayflies of the Genus Baetis

While gathering material for a study of May-fly embryology, some observations were made on the habits of a species of Baetis. This led to rearing experiments that were carried through successive generations for two and one-half years. A comparative study was made of two other species of the same genus.

The determination of these species as *B. posticatus, B. pygmaea,* and *B. propinquus* was made by detailed comparison with specimens in the Cornell University collection.

## BAETIS POSTICATUS.

The mating flight of *B. posticatus* was observed late in the afternoon of May 6, 1918. Males and females flying together rythmically rose and fell in vertical lines. In numbers varying from hundreds to two or three, they danced fitfully up and down; sometimes rising short distances above the surface of the water; sometimes soaring exultantly out of sight. Then they dropped with wings out spread. A female left the throng followed by a male. He flew up from below and grasped her prothorax with his forelegs. The posterior of his abdomen was flexed up and forward. His tails were extended on either side of the head of the female. Then he seized the seventh segment of her abdomen with his forceps. The egg-valve was pushed open and the penes inserted into the sperm receptacle in the seventh segment. The female continued to fly, carrying the male along with her. In this manner they copulated for about a minute; then the male rejoined the dance, and the female flew away to deposit her eggs. She alighted on a partially submerged stone, wrapped her wings about her abdomen, and crawled into the water. After walking about feeling the stone with the tip of her abdomen, she suddenly stopped and braced her legs. As the abdomen swayed from side to side, the eggs came from the oviducts. They were pressed to the surface of the stones. The masses are irregularly ovoid (Fig. 21), and contain from eighty to three-hundred eggs. These eggs are covered with a sticky substance which causes them to adhere to each other and to the stones. Some of the females were washed away while ovipositing; others managed to crawl weakly out of the water. The males continued their flight until exhaused. Shortly after sun-down the dead bodies of all floated away in the current.

A stone coated with freshly laid egg-masses was covered loosely with a piece of china silk, and submerged in the running water of the creek. Nymphs hatched in twenty-eight days. They were left in the silk covering until too large to escape through fine wire mesh. Then they were transferred to cylindrical

breeding cages of wire cloth, six inches long and three inches in diameter. These cages were covered top and bottom with canvas. A small stone with algae was placed in the bottom, and the cage, half submerged, was anchored in the stream. As the nymphs neared maturity, they were separated into groups of four to a cage.

For a more detailed study, an egg-mass was carefully loosened from a stone and transferred to a Syracuse watch glass in the laboratory. The water was changed twice daily. Nymphs appeared in eleven days as contrasted with twenty-eight days in the cooler water of the creek. As soon as hatched, the nymphs were transferred to Syracuse watch glasses, ten nymphs to each glass. The water was changed twice daily, and fresh bits of green algae added every other day. When the fifth instar was reached, the nymphs were separated into groups of two per dish. The cast skins of each specimen were kept separate. Table A is a summary of the number and length of the stadia.

A nymph of the first instar (Fig. 8) is .74 mm. in length including antennae and tails. It has no gills and no middle tail. The nymphs are very active, and start eating almost immediately. The food consists of diatoms at first; then green algae and decaying higher plant tissue are added in gradually increasing quantities.

A nymph of the fifth instar is 1.5 mm. long including antennae and tails. Gills show as tiny outpockets of the body wall, and the middle tail is evident for the first time. The color pattern is faintly visible. As the nymph grows older, this color pattern is more clearly defined. There is however, much individual variation in the differentiation of the pattern. At the seventh instar the gills reach their full relative size, and are freely moved.

Nymphs of the same instar are not uniform in length. This becomes apparent at the fifth stadium. The critical stage is at molting. This takes place generally during the warmer part of the day.

Specimens kept in cages and nymphs free in the stream began emerging October 22, 1918. The main pulse started October 25, and continued for four days; stragglers appeared even ten days later.

A nymph ready to transform (Fig. 20) swims to the surface of the water. Strong pulsations in the dorsum of the prothorax cause a rent in the nymphal skin. The subimago emerges and flutters through the air to some support. There it sits with wings uplifted and forelegs thrust stiffly forward, waiting for the subimaginal molt. This takes place from eighteen to twenty-four hours later. Then the imago or true adult emerges and the mating flight follows.

A mass of eggs laid October 28, 1918, was brought into the laboratory for the purpose of rearing the nymphs. These specimens emerged during the second week in May. There were again twenty-seven stadia (Table A).

Nymphs reared in the creek from eggs laid October 28, 1918, did not emerge until August, 1918. A new cycle started in August was completed the following May.

It is evident that the cycle started October 28, 1918, was completed in the laboratory in the same length of time as that of the previous cycle extending from May-October in the creek; but that the corresponding cycle (Oct. 28) in the creek was completed three months later.

A summary of the corresponding yearly cycles (Table B) and the continuous cycles (Table C) for the years 1918-1920 inclusive, together with the average monthly temperatures, shows a striking ratio between the length of cycle and the temperature. One six month cycle confined entirely to the warm months, is followed by two nine month cycles extending through the winter. Two years are necessary to complete three continuous cycles (Fig. 3). There are three periods of emergence during a year.

Four females captured during a mating flight October 28, 1918, were found to be parasitized. Each imago contained a single nematode coiled up in the body cavity (Fig. 16). The hosts appeared natural in flight, and it was not until the specimens were preserved that the presence of the parasite was observed. The abdomen, normally conspicuously filled with eggs, seemed to contain nothing except the nematode.

## B. PYGMAEA AND B. PRONPINQUUS.

Associated with nymphs of *B. posticatus* are nymphs of *B. pygmaea* and *B. propinquus*. An examination of a series of reared specimens of these three species fails to reveal specific characters which are valid at any given instar. Mature and fully colored nymphs may be separated by the relative characters given in Table D. A microscopic examination of the mouth-parts shows slight variations in the form of the labial palp (Figs. 13, 14, 15), and in the maxilla (Figs. 17, 18, 19).

The venation of the hind wing of the male (Figs. 4, 5, 6) and female, and the genitalia of the male (Figs. 1, 2, 12), furnish definite specific characters in the imago. There is also a variation in the relative length of the first and second leg in the males of these species (Figs. 9, 10, 11).

The oviposition of *B. pygmaea* is described by Morgan in 1911 (3); the mating flight of a species of Baetis by the same author in 1913 (4).

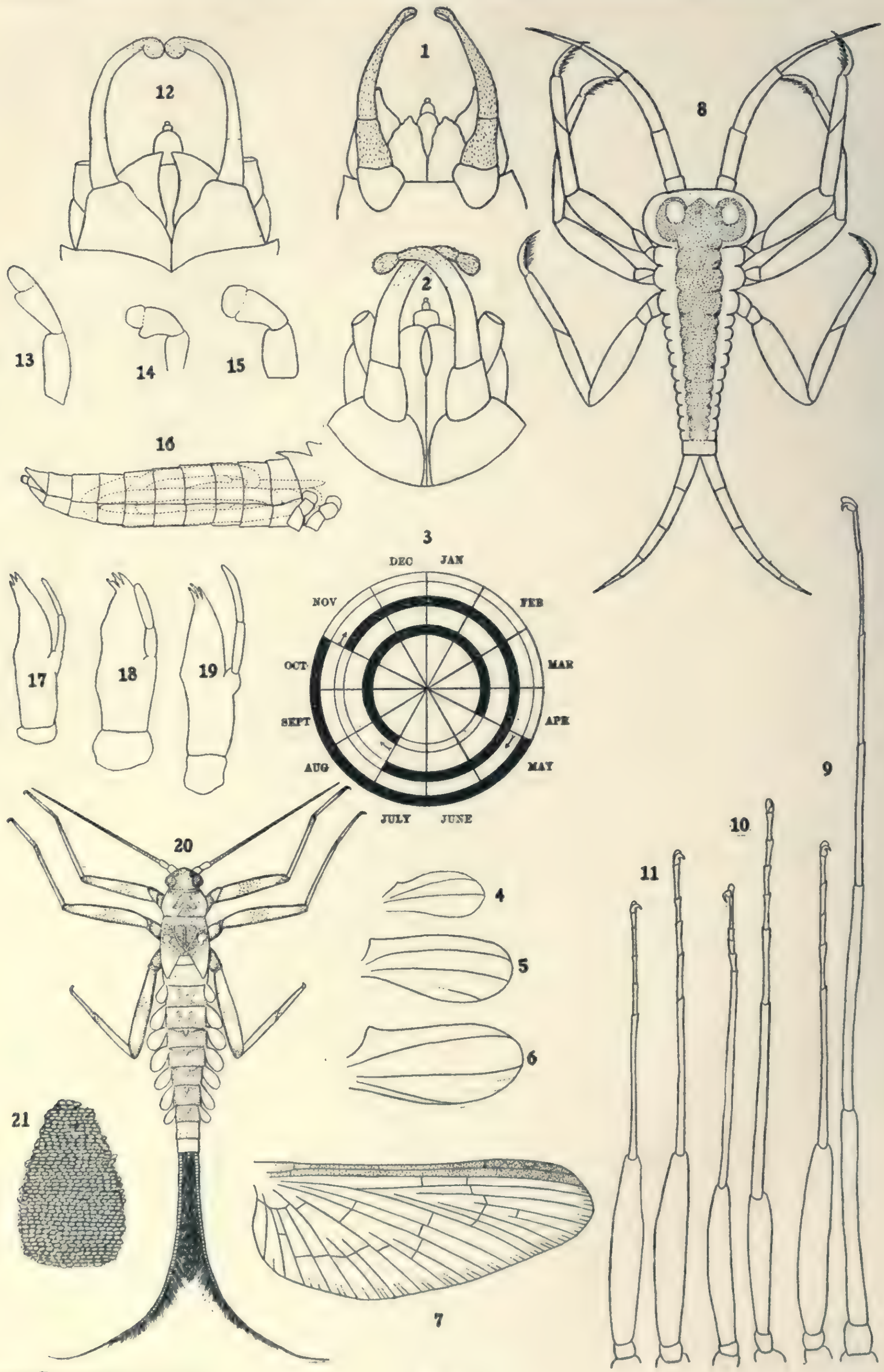
The life cycle of *B. pygmaea* reared in the creek extending from August, 1919 to August, 1920; that of *B. propinquus* from September, 1919 to August, 1920. Change of residence prevented further rearing experiments to determine the number of stadia in these two species, and whether there are overlapping cycles.

## LITERATURE CITED

(1) *Clemens, W. A.* Canad. Entomol., 45:340-341. 1913.
(2) *Eaton, A. E.* Monogr. Recent Ephemeridae. 1885, p. 169.
(3) *Morgan, A. H.* Ann. Ent. Soc. Amer., 4:116. 1911.
(4) *Morgan, A. H.* Ann. Ent. Soc. Amer., 6:393. 1913.
(5) *Needham, J. G.* Bull. No. 47, N. Y. State Mus. 1901, p. 423.

## EXPLANATION OF PLATE

1. Diagram, genitalia ♂ imago, *B. pygmaea.*
2. Diagram, genitalia ♂ imago, *B. posticatus.*
3. Diagram, life cycle, *B. posticatus,* May, 1919-May, 1920. Arrows indicate three successive broods.
4. Venation, hind wing ♂ imago, *B. pygmaea.*
5. Venation, hind wing ♂ imago, *B. propinquus.*
6. Venation, hind wing ♂ imago, *B. posticatus.*
7. Venation, fore wing ♂ imago, *B. posticatus.*
8. Diagram, 1st instar nymph, *B. posticatus.*
9. Diagram, 1st and 2nd leg ♂ imago, *B. propinquus.*
10. Diagram, 1st and 2nd leg ♂ imago, *B. pygmaea.*
11. Diagram, 1st and 2nd leg ♂ imago, *B. posticatus.*
12. Diagram, genitalia ♂ imago, *B. propinquus.*
13. Diagram, labial palp nymph, *B. pygmaea.*
14. Diagram, labial palp nymph, *B. posticatus.*
15. Diagram, labial palp nymph, *B. propinquus.*
16. Diagram, nematode in ♂ imago, *B. posticatus.*
17. Diagram, maxilla nymph, *B. propinquus.*
18. Diagram, maxilla nymph, *B. posticatus.*
19. Diagram, maxilla nymph, *B. pygmaea.*
20. Diagram, mature nymph, *B. posticatus.*
21. Diagram, egg mass, *B. posticatus.*


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
DEC
JAN
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV

## TABLE A

Summary of Number and Length of Stadia, *B. posticatus* Laboratory Reared Specimens

| Stadium | Days | | Length Body | | Per Cent. Death Rate | |
|---|---|---|---|---|---|---|
| | (1) May 1918–October 1918 | (2) October 1918–May 1919 | May 1918–October 1918 | October 1918–May 1919 | May 1918–October 1918 | October 1918–May 1919 |
| 1 | 2 | 2 | .30 | .30 | 2.4 | 1.2 |
| 2 | 2-3 | 2 | .40 | .40 | 1.2 | 0.6 |
| 3 | 4-6 | 3-5 | .50 | .50 | 0.9 | 0.3 |
| 4 | 4-6 | 4-5 | .60 | .60 | 3.1 | 0.0 |
| 5 | 6-7 | 4-6 | .71 | .70 | 0.0 | 0.8 |
| 6 | 7-8 | 4-7 | .84 | .82 | 0.6 | 0.4 |
| 7 | 6-10 | 5-7 | 1.3 | .95 | 0.0 | 0.2 |
| 8 | 6-10 | 6-8 | 1.7 | 1.2 | 0.2 | 0.2 |
| 9 | 6-10 | 6-8 | 2.1 | 1.5 | 0.3 | 0.0 |
| 10 | 6-11 | 6-9 | 2.5 | 1.8 | 0.2 | 0.0 |
| 11 | 7-10 | 8-11 | 2.9 | 2.1 | 0.1 | 0.0 |
| 12 | 7-11 | 8-10 | 3.3 | 2.4 | 0.3 | 0.0 |
| 13 | 6-10 | 8-11 | 3.7 | 2.7 | 0.0 | 0.3 |
| 14 | 7-10 | 8-11 | 4.0 | 3.0 | 0.0 | 0.1 |
| 15 | 7-10 | 7-10 | 4.3 | 3.3 | 0.0 | 0.0 |
| 16 | 7-10 | 7-10 | 4.6 | 3.7 | 0.0 | 0.0 |
| 17 | 7-10 | 8-10 | 4.9 | 4.0 | 0.0 | 0.1 |
| 18 | 7-10 | 8-10 | 5.1 | 4.3 | 0.0 | 0.0 |
| 19 | 7-10 | 8-10 | 5.4 | 4.7 | 0.0 | 0.0 |
| 20 | 7-10 | 8-10 | 5.6 | 5.0 | 0.0 | 0.0 |
| 21 | 7-10 | 8-10 | 6.0 | 5.3 | 0.1 | 0.0 |
| 22 | 7-10 | 8-10 | 6.3 | 5.7 | 0.0 | 0.0 |
| 23 | 7-10 | 8-10 | 6.6 | 6.1 | 0.0 | 0.0 |
| 24 | 7-10 | 8-10 | 6.9 | 6.3 | 0.0 | 0.0 |
| 25 | 7-10 | 8-10 | 7.2 | 6.5 | 0.0 | 0.0 |
| 26 | 7-10 | 8-10 | 7.5 | 6.8 | 0.0 | 0.0 |
| 27 | 7-10 | 8-10 | 7.8 | 7.0 | 0.0 | 0.1 |

## TABLE B

Summary of Corresponding Yearly Cycles, *B. posticatus*, at Ithaca, N. Y.

| Cycle | Months | Av. Mon. Temp. |
|---|---|---|
| May, 1918-October, 1918 | 6 | 60.7 |
| May, 1919-October, 1919 | 6 | 63.5 |
| May, 1920-October, 1920 | 6 | 62.4 |
| August, 1918-May, 1919 | 9 | 45.0 |
| August, 1919-May, 1920 | 9 | 41.4 |
| October, 1918-August, 1919 | 9 | 47.9 |
| October, 1919-August, 1920 | 9 | 43.3 |

(1) 376 Specimens. (2) 237 Specimens.

## TABLE C

Summary of Continuous Cycles, *B. posticatus,* at Ithaca, N. Y.

| Cycle | Months | Av. Mon. Temp. |
|---|---|---|
| Brood 1—May, 1918-October, 1918 | 6 | 60.7 |
| Brood 2—October, 1918-August, 1919 | 9 | 47.9 |
| Brood 3—August, 1919-May, 1920 | 9 | 41.4 |
| Brood 4—May, 1920-October, 1920 | 6 | 62.2 |

## TABLE D

Distinguishing Characters of Species of Baetis at Ithaca, N. Y.

| | Nymph | | | Imago | | |
|---|---|---|---|---|---|---|
| Species | Length Body | Tail | | Length | | |
| | | Length | Color | Hind Wing | Body | Tail |
| pygmaea | 4-5 | 2.3-2.5 | 3 dark bands | 0.6 | 3-5 | 7 |
| propinquus | 6 | 2 | 3 dark bands | 1.0 | 4-5 | 7.5-10.2 |
| posticatus | 6-8 | 4-5 | no bands | 1.3 | 8 | 19 |

BULLETIN NO. 23 1923 ENTOMOLOGICAL SERIES NO. 3

# BULLETIN

of the

# LLOYD LIBRARY

of

## BOTANY, NATURAL HISTORY PHARMACY AND MATERIA MEDICA

FOUNDED, ENDOWED AND MAINTAINED

BY

CURTIS G. LLOYD

ENTOMOLOGICAL SERIES, No. 3

# MORPHOLOGY, ANATOMY AND ETHOLOGY OF NEMOURA

BY

CHENFU FRANCIS WU

# CONTENTS

CONTENTS

# Morphology, Anatomy and Ethology of Nemoura[1]

Chenfu Francis Wu

## INTRODUCTION

Some of the workers on the order Plecoptera have occasionally given their attention to the small and inconspicuous genus Nemoura, but most of them have limited themselves to the description of the species. External characters have been used for systematic purposes, but no detailed studies of the body sclerites have been made and the structure of the internal organs as well as the life histories of the species are yet unknown.

In this work, an attempt has been made to bring out the external and internal structural characters of the genus by a study of its representative species, to homologize these structures with those of more generalized insects as described by recent investigators, and to make known the life history and biology of the species that has been studied throughout all the stages of its post-embryonic development. The work was carried on from March, 1921, through April of the following year. Besides N. *venosa* Banks, two undescribed species, N. vallicularia and N. sinuata, were collected in the vicinity of Ithaca, New York.

Nemoura *vallicularia* was chosen for study and its life history has been completely worked out. The results, herewith presented in this paper, are derived from an intensive study of this single species and are discussed in three different parts: Part I, External Morphology; Part II, Internal Anatomy, and Part III, Ethology.

The most useful references for the different subjects of discussion in this paper are given at the beginning of each part or its subdivisions. These, together with the other references consulted, are listed in the bibliography. The various methods employed in the study of the different subjects are also given at the beginning of each part or its subdivisions. The differences, that have been noted between N. vallicularia and the other two local species, are given in the foot-notes at the proper places of this discussion. All the drawings were made to scalė on cross-section paper and the eye-piece micrometer was used in the microscope.

[1] Contribution from the Entomological Laboratory of Cornell University. This investigation was suggested by and carried on under the direction and supervision of Professor J. G. Needham, to whom the writer is indebted for his helpful suggestions and kindly criticism. The writer is also indebted to Professors O. A. Johannsen and P. W. Claassen for their advice and guidance throughout the progress of the work.

# PART I. EXTERNAL MORPHOLOGY

In Nemoura there are represented most of the generalized and typical characters of Plecoptera. The adult has a more or less depressed head, three distinct thoracic segments, two pairs of membranous wings, three pairs of slender legs and an abdomen composed of ten apparent segments. A pair of long and slender antennae and three ocelli are present in the head with the mouth parts fitted for biting. The wings are folded horizontally on the back at repose, reaching far beyond the tip of the abdomen. There are few cross-veins in the wings and the veins of the pterostigma form an X which is characteristic of the genus. The hind wings are much broader than the front ones. The second tarsal joint is extremely short and the cerci borne at the tip of the abdomen are each composed of a single segment. The metamorphosis is incomplete and the immature stages are passed in water. The naiad has a pair of shorter and tapering antennae, three pairs of short and stout legs, two pairs of wing pads on the caudo-lateral borders of the mesothoracic and metathoracic tergites, and a pair of long tapering cerci at the caudal end of the abdomen. External tracheal gills may or may not be present on the anterior border of the prosternum.

Almost all, that has been written on this genus during the past, has been descriptions of the species and are therefore of very little morphological value. Klapalek, who first used the genital characters for separating the species, published a paper in 1896 on the morphology of the genital appendages of Plecoptera, in which he gave a very good account on the reproductive organs and genitalia of the European species. Recently Crampton and Walker have also worked on the genital structures of the American species and their related forms with greater emphasis laid on the study of phylogeny. In connection with the present work, the papers by Snodgrass (1909, 1910), Crampton (1918), Taylor (1918), and Walker (1919, 1922), have been found to be extremely useful.

For studying the external structural characters, specimens are either preserved directly in 80% alcohol, or killed and fixed in warm Diedrich's Solution (40% Formalin, 12 cc; 95% alcohol, 30 cc; glacial acetic acid, 2 cc; distilled water 60 cc) for six hours before being transferred to and kept in 80% alcohol. Specimens treated with the Diedrich's Solution are well relaxed and hardened to certain extent, so they are far more satisfactory for the work. Specimens have also been boiled in caustic potash and the sutures are found to show up very distinctly.

In the following account, the head is described in a normal position, with the front looking dorsad and the distal margin of the labrum pointing cephalad. For illustrations of the morphological characters see figures 1-61.

## A. The Head.

### 1. The Sclerites of the Head (Figs. 1 to 8).

*The Epicranium.* The vertex, the occiput and the genae are closely fused into a single large piece, the epicranium, which forms the main portion of the head capsule. The coronal suture, or the stem of the Y-shaped epicranial suture extends from the occipital foramen upward and forward along the median line to near the center of the dorsal surface of the head, where it branches into two frontal sutures, or the arms of the epicranial suture. These frontal sutures proceed cephalo-laterad and can be distinctly traced to as far as the lateral ocelli. In the naiads, they can be traced to the bases of the antennae.

*The Front.* The front is a triangular sclerite, bounded on the sides and behind by the diverging frontal sutures and in front by the clypeal suture. It is slightly concave at the middle and it bears the three ocelli.

*The Clypeus.* The clypeus is situated cephalad of the front and is separated from it by the clypeal suture. It is partly divided by a transverse suture into an anteclypeus and a postclypeus.

*The Antennal Sclerites* (Basantenna, Antennifer). At the base of each antenna on the cephalo-lateral border of the head, there is an annular antennal sclerite. It is not chitinized and is light yellow in color.

*The Mandibular Sclerites* (Trochantin of the Mandible, Basimandible, Mandibulare). Below the antennal sclerite, there is a triangular mandibular sclerite, to which the mandible is articulated. It can be seen distinctly when the head is viewed from the side.

*The Maxillary Pleurites* (Trophifer). Immediately behind the maxilla on each side of the head, there is a long narrow sclerite, the maxillary pleurite, which forms the articulation of the maxilla.

*The Jugular Sclerites* (Cervical Sclerite, Laterocervicale, Intersegmental Plate). The head is joined to the prothorax by a membranous neck, on each side of which there is a slightly chitinized jugular sclerite.

### 2. The Eyes (Figs. 1 to 8).

*The Compound Eyes.* Two large compound eyes are situated on the sides of the head. In a lateral view of the head, the compound eye is seen to be reniform in outline, being slightly concave on the posterior margin.

*The Ocelli.* On the dorsal surface of the head, there can be found three ocelli; an unpaired median ocellus, situated right at the center of the front; and two lateral ocelli, situated one on each side on the frontal suture. The three ocelli are almost equidistant from each other. The naiads do not possess ocelli, although in the older naiads the ocelli of the adults can be seen to be developing beneath the skin.

3. The Appendages of the Head (Figs. 9 to 24).

*The Antennae.* The antennae are black, filiform and pubescent all over. They are also very long, about half as long as the whole body including the wings. The number of segments is not constant and is about thirty-nine in each. The scape is unusually large, with a diameter at least twice that of the following segments. The pedicel is very short and the third segment is about twice as long as the pedicel. The following segments gradually increase in length to near the distal end where they begin to shorten again. The antennae of the naiads are setaceous in form, with about fifty-two segments in each. The scape is also very large and is the only segment that is pubescent all over. The following segments gradually increase in length to the tip, each with a whorl of short bristles around its distal end.

*The Labrum.* The labrum is articulated to the anterior border of the clypeus and is separated from it by the clypeo-labral suture. Its upper surface and margins are covered with hairs, and on its ventral side there is at the center a large circular sense pit, with numerous sense hairs. Between this sense pit and the anterior margin there is another circular group of sense papillae. In the naiad there are two groups of these sense papillae.

*The Mandibles.* The mandible is heavily chitinized and is provided with several pointed teeth at the distal end and a ridged molar surface behind the teeth. Dorsally it is articulated to the invagination of the anterior arm of tentorium at the cephalo-lateral border of the front, and ventrally it is articulated to the mandibular sclerite by a knob-like condyle.

*The Maxillae.* Each maxilla is composed of the following parts: (1) *cardo,* (2) *stipes,* (3) *maxillary palpus,* (4) *subgalea,* (5) *galea,* (6) *lacinia* and (7) *digitus.* The maxillary palpus consists of five segments and is pubescent all over. The two basal segments are short while the three distal ones are subequal in length, each about twice as long as one of the basal segments. The subgalea and galea are both pubescent and the galea is provided with sense papillae at the tip. Like the cardo, the lacinia is more heavily chitinized than the rest, with a row of bristles on its inner margin. The digitus is bifid and is borne at the distal end of the lacinia.

*The Hypopharynx.* The hypopharynx lies above the labium and between the maxillae. It is a tongue-like organ with a ventro-median process, extending backward.

*The Labium.* The labium is pubescent all over and consists of (1) a large semi-membranous *submentum,* (2) a small narrow *mentum* more or less fused with the ligula in front, (3) a pair of *labial palpi* and (4) the compound *ligula.* The basal segment of the labial palpus is large, the second and third are smaller and shorter, and the fourth or last segment is the largest of all, being circular in shape, greatly flattened and provided with sense papillae. The ligula consists

of a pair of inner lobes, the glossae, and a pair of outer lobes, the paraglossae. The glossae and paraglossae are partly fused with each other with indistinct sutures between them and sense papillae at their distal ends. In the naiad, the last segment of the labial palpus is neither circular in shape nor greatly flattened, but is broad at the base and somewhat truncate at the tip.

## B. The Thorax.

The mesothorax represents a typical wing-bearing thoracic segment and is herewith described in detail. The differences, that exist in the other thoracic segments, are also noted in the course of discussion.

### 1. The Sclerites of the Tergum (Figs. 1 to 8).

The *prescutum* is the anterior transverse sclerite of the tergum. It is divided by a longitudinal suture on the meson and is preceded by the prephragma, which is visible only when the specimen is well relaxed.

The *scutum* and the *scutellum* are closely fused together to form the large prominent part of the tergum. These sclerites can only be distinguished from each other by slight depressions along the lines of fusion. The scutum is produced laterally into the anterior notal processes, and the scutellum is produced laterally into the posterior notal processes. In the metathorax, the posterior notal processes are bifid.

The *postscutellum* is the next and last sclerite of the tergum. Its central portion is very weakly chitinized and is much lighter in color than the surrounding parts. In the metathorax the postscutellum is partly fused with the postphragma that lies on its posterior margin.

In the prothorax, all the tergal sclerites are completely fused together to form a single piece, the *pronotum*. It is highly chitinized and almost quadrangular in outline, with smooth margins and rounded angles. The disc is rugose and convex, sloping toward the sides. A narrow strip on its posterior margin fails to be chitinized.

In the naiad, the pronotum is fringed on the margins with bristles of equal lengths. It is also traversed by a median suture line, along which the old skin splits while molting.

### 2. The Sclerites of the Pleurum (Figs. 1 to 8).

The *pre-episternum* and *episternum* are partly fused to form a large triangular piece, that constitutes the anterior and the greater part of the pleurum. The suture between them is distinct only about half way from the top and the pre-episternum is a darker narrow sclerite in front of the episternum. The episternum is indistinctly divided by an impressed line into an upper and a lower part, the *an-episternum* and the *kat-episternum*.

The *epimerum* lies dorso-caudad of the episternum and is separated from it by the episternal suture. Together with the episternum, it is produced dorsad into the *pleural wing process* and ventrad into the *pleural coxal process.* The epimerum is also divided into an upper and a lower part, the *an-epimerum* and the *kat-epimerum.* The an-epimerum is weakly chitinized on its dorsal and ventral margins.

In the pleurum of the prothorax, there are only two well-defined chitinized sclerites, the episternum (Curvipleurite) and the kat-epimerum. The episternum is modified into a curved quadrilateral sclerite lying almost transversely on the side of the prothorax. Near its posterior margin, there is a small pit which is the invagination of the lateral apodeme.

In the naiad, the pre-episterum and the episternum can not be distinguished from one another in the mesothorax and metathorax.

3. The Sternum (Figs. 1 to 8).

All the sclerites on the ventral side of the thoracic segment are completely fused into a single large piece, the *sternum.* The furcal pit is situated on its posterior margin.

In the prothorax, the presternum, eusternum and sternellum are fused together to form the triangular-shaped sternum. Behind this there exists another sclerite, the *post-sternellum,* which is situated on the conjunctiva between the prothorax and the mesothorax. The post-sternellum is narrow and crescent-shaped. It bears another furcal pit, the invagination of the *post-profurca* (according to Berlese).[2]

4. The Articular Sclerites of the Legs (Figs. 1 to 8).

Besides being articulated dorsally to the pleural coxal process and caudally to the kat-epimerum, each leg is also articulated anteriorly and ventrally to a triangular sclerite, the *trochantin,* the apex of which is produced downward to lie between the sternum and the coxa. In the prothorax, the pleural coxal processes are absent, owing to the modification of the pleural sclerites.

5. The Articular Sclerites of the Wings (Figs. 1 and 8).

*The Ossicles.* At the base of each wing on the dorsal surface, there are three small triangular sclerites, the ossicles. Two of these are arranged in a front row and the third one is situated behind them. The proximal one in the front row is the *notopleural ossicle* (notopleurale, first axillary), articulating with the anterior notal wing process and the base of subcosta. The distal one in the front row is the *median ossicle* (medipterale, second axillary), articulating

[2] In N. venosa and N. sinuata, the naiad has a pair of tracheal gills on the cephalo-lateral borders of the prosternum. These persist in the adult stage as vestigial prosternal gills.

proximad with the notopleural ossicles, distad with the base of radius and media, ventrad with the pleural wing process, and caudad with the adanal ossicle. The *adanal ossicle* is the third one behind the front row. It articulates with the posterior notal wing process and the base of the anal veins.

*The Alares.* In front of the pleural wing process between the pre-episternum and the wing base, there is a small sclerite, the *pre-alare*. Behind the pleural wing process between the epimerum and the wing base, there is also a narrow sclerite, the *sub-alare*. These sclerites were called paraptera by Snodgrass. In the mesothorax in front of the pre-alare and the humeral angle of the wing, there exists another narrow chitinized sclerite. It is greatly arched and serves as a connecting link between the prescutum above and the pre-episternum below. This was called the pre-alar bridge by Crampton (1920).

6. The Legs (Figs. 25 to 28).

The legs are long and slender and are covered all over with short hairs. Each leg is composed of five distinct parts, which are separately described below.

The *coxa* is the proximal segment of the leg and is divided into an upper membranous part, the *meron,* and a lower cone-shaped chitinized piece, the *veracoxa* (eucoxa).

The *trochanter* constitutes the second part of the leg and is a small triangular segment.

The *femur* is the third and heaviest part of the leg, being convex above, slightly compressed on the sides and flat beneath. Its sides are parallel.

The *tibia* forms the next part and is slender, cylindrical and longer than the femur. It is provided with a pair of *tibial spurs* at its distal end on the ventral side.

The *tarsus* is the fifth and last part of the leg and is composed of three segments. The first and the third segments are long and sub-equal in length, while the second segment is small and short, being only one-third as long as the others. The third segment bears a pair of *tarsal claws* (ungues) and a *pulvillus* (onychus), which projects between the claws.

In the naiads, the leg is short and robust, with heavy bristles and very few scattered hairs. The coxa is not divided and the femur is greatly arched and heavily bristled above. The tibia is furnished with four longitudinal rows of bristles besides the tibial spurs. The second tarsal segment is the smallest of the three, about half as long as the first segment. The third tarsal segment is about three times as long as the first. The pulvillus is wanting.

7. The Wings (Fig. 1).

The fore-wings are long and narrow while the hind-wings are shorter with enlarged anal areas. The upper surfaces of the wings are thickly covered

with minute hairs, with heavier spines on the veins. The wings are also fringed with hairs which are longer on the inner margins. The inner margins are thickened and corrugated at the base to form the axillary cords, which are joined to the caudal margins of the posterior notal processes.

*Venation.* In the front wing the costal vein is located on the margin and forms its thickening. The subcostal vein divides into two branches beyond the middle of the wing. Vein $Sc_1$ extends forward to the costal margin while vein $Sc_2$ bends backward to anastomose with vein $R_1$ before extending forward to the costal margin. The cell, thus formed by the costa and the two branches of sub-costa, has been called the *pterostigma.* The stem of media coalesces with that of the radius for a short distance at the base. The radial sector and the media are each two-branched. The cubitus is also two-branched, with its base more or less atrophied. The first and second anal veins arise together at the base and extend separately to near the inner margin, where they become united again.[8]

The third anal vein coalesces with the second at the base and then separates out as a short branch of the latter, extending to the inner margin of the wing. The cross-veins present are the *humeral, radial, radio-medial, medio-cubital,* and *cubito-anal.* The veins $Sc_1$, $Sc_2$, r, r-m, and $R_{4+5}$ are arranged in such a way that they form the characteristic X in the region of the pterostigma. Many cross-veins are also present in the medio-cubital (between the stem of media and vein $Cu_1$) and the cubital (between the veins $Cu_1$ and $Cu_2$) regions but these cross-veins are not constant in number. There is a cross-vein between the first and the second anal veins, and the cell thus closed is called the *basal anal cell.*

In the hind wing, the stem of media coalesces further with the radial sector and separates out from it near its base. In the medio-cubital and the cubital regions, usually there is only one cross-vein in each. The second and third anal veins are each two-branched and the anal area is greatly enlarged.

*Corrugations and furrows.* In the fore-wing there are two folds and one furrow: the sub-costal fold between veins Sc and $R_1$; the cubito-anal fold between veins $Cu_2$ and 1st A; and the median furrow in front of the median stem and almost coincident with it. The hind wing is folded upon itself three times, so besides the above mentioned there are two other folds in the anal area of the hind wing. One of them is immediately behind the first branch of the third anal vein and the other is immediately behind the second branch of the third anal vein. The actual folding of the hind wing takes place along the cubito-anal fold and the other two anal folds. The median furrow crosses the cross-vein r-m, and produces on it near its junction with media a weakened place, the bulla.

*Tracheation in the wing-pads of the naiad.* When the wing-pads of the naiad attain their full size and before the developing wings become folded in

[8] In N. venosa and N. sinuata, they do not unite but reach the margin separately.

the pads, the tracheae that precede the wing veins can be studied to the best advantage for determining the identity of the different veins. This study of tracheation was first made by Comstock and Needham (1898-1899) and the tracheation of Nemoura was very thoroughly worked out. The writer has only repeated the study in Nemoura and is confirming their accurate results, which are summed up in the following:

The sub-costa, radius and media arise from the costo-radial trachea while the cubitus and the anals arise from the cubito-anal trachea. There is no basal transverse trachea connecting the costo-radial and the cubito-anal tracheae. The costal trachea and all the tracheae in the cross-veins are absent. Trachea $Sc_2$ is separated from $R_1$ though nearly anastomosing with it. The stem of media is separated from that of the radius but switches forward to almost anastomose with it, foreshadowing the fusion of the two stems in the adult wings. In the hind wing-pad, the switching of the radial sector to the stem of media also predicts a future coalescence of the two veins in the adult stage.

## C. The Abdomen.

### 1. The Abdominal Segments of the Adults (Figs. 1, 3, 5).

The abdomen consists of eleven segments, ten of which are distinctly recognizable, while the last one is fused with the tenth tergite in the female and is modified into the supra-anal lobe in the male. Normally each segment is ring-like and is composed of a *tergite* (the dorsal half) and a *sternite* (the ventral half), which are closely fused together on the sides.

In segment one of both sexes the tergite and the sternite are widely separated by the insertion of the hind coxae on the sides. The tergite is thus reduced to a small dorsal sclerite, while the sternite fuses completely with the metasternum of the thorax, and partly with the sternite of the following segment.

In the male, segments two to eight are heavily but unevenly chitinized and the tergites of these segments are more or less triangularly produced backward.[4]

In the female, segments two to six are evenly chitinized and ring-like.

### 2. The Genitalia (Figs. 30 to 61).

Segments nine to eleven in the male and segments seven to eleven in the female are modified for genital purposes and are therefore collectively called the genitalia. So far the homology of the genital parts is not yet well established in different orders of insects. Klapalek's terminology is herewith adopted and the names suggested by other authors are given as synonyms in parentheses.

[4] In N. venosa and N. sinuata these segments are evenly chitinized and the tergites are not produced backward.

(a) The male genitalia.

*The Male Sub-genital Plate.* The ninth sternite is modified into an oval plate, which tapers backward and bends upward in almost a right angle with the chitinized *penis* at the tip.[5] This is the male sub-genital plate (coxosternum, hypandrium) with a small *median white lobe* extending backward from its anterior border.

*The Tenth Segment.* Dorsally the tenth segment is partly fused with the supra-anal lobe behind, and ventrally it is totally absorbed. It is distinctly recognizable on the sides.

*The Supra-anal Lobe.* The supra-anal lobe is derived from the eleventh segment and is partly fused with the tenth tergite in front. On the meson, it is divided by a suture into two *paragenital plates* (according to Walker) which form together a *mid-dorsal groove.* The supra-anal lobe is produced into a caudal process, which extends in a backward and upward direction and has been called the "sperm conveyor" by Smith (1918) and Walker (1922).[6] It has, however, been observed to function during copulation not as a sperm conveyor but as a supporter of the female ninth sternite. It is therefore called here the *"supra-anal process."*

*The Sub-anal Lobes.* Between the supra-anal lobe and the male sub-genital plate, there is on each side of the anus a sub-anal lobe (podical plate, paraproct), the origin of which is still disputed. Its distal end is heavily chitinized and modified into a flask-shaped structure which recurves upward and forward and has been called the *copulatory hook* by Walker (1922).[7]

*The Cerci.* During transformation each cercus is reduced to a single segment and is borne on a basal sclerite, the *cercal basipodite* (according to Walker), which is closely fused with the sub-anal lobe.[8]

(b) The female genitalia.

*The Female Sub-genital Plate.* The seventh sternite of the female is modified into the female sub-genital plate, which is only analogous to the sub-genital plate of the male. It is not separated from the rest of the segment by

---

[5] In N. venosa and N. sinuata it does not bend upward and the penis does not project beyond its tip.

[6] In N. venosa and N. sinuata, this process is recurved forward to lie in the mid-dorsal groove. In N. venosa, it is armed with short and heavy spines.

[7] In N. venosa, the sub-anal lobe is provided with two chitinous bands; a narrow outer band and a broad inner band which looks truncate behind in a ventral view. Both of these bands are armed with spines and are recurved upward to end in a small rounded knob above the cercus. In N. sinuata, it is provided with two narrow chitinous bands, which are also armed with spines. The inner one is short and curved while the outer one is long, sinuated and recurved upward (Figs. 34 to 41).

[8] In N. sinuata, the cercal basipodite is a distinct and chitinized sclerite at the base of the cercus, being separated from the supra-anal lobe by a membrane.

any suture, but is triangularly produced backward to conceal the eighth sternite and slightly overlap the ninth.[9]

*The Vaginal Valves.* The eighth sternite is provided at the middle with two small valves, the vaginal valves, and is concealed by the posteriorly produced seventh sternite.[10]

*The Ninth Segment.* The ninth sternite is slightly rounded out in front to be overlapped by the sub-genital plate, and is provided with two characteristic black spots, one on each side near the anterior margin.[11]

*The Tenth Segment.* The tenth segment retains its ring-like character with a narrow sternite. Its tergite is closely fused with the eleventh segment to form together a dorsal triangular piece, the supra-anal lobe.

*The supra-anal lobe* can not be distinguished from the tenth tergite, and according to Crampton it is the membranous portion of the ventral surface of the tenth tergite.

*The Sub-anal Lobes.* Below the supra-anal lobe and on each side of the anus, there is a sub-anal lobe, which is triangular in shape and is homologous to those greatly modified ones in the male.

*The Cerci.* Each cercus consists of a single segment and appears to be borne by the sub-anal lobe, with which the cercal basipodite is closely united.

3. The Abdomen of the Naiads.

Like the adult, the naiad has the tergite and the sternite of the first abdominal segment widely separated by the insertion of the hind coxae on the sides. The tergite is a distinct sclerite while the sternite is fused with those in front and behind. Segments two to nine are all normal and ring-like. Segment ten is also ring-like, but its sternite is narrow while its tergite is closely fused with segment eleven to form the triangular supra-anal lobe. Below the supra-anal lobe and on each side of the anus, there is a triangular sub-anal lobe. The cerci are about half as long as the body, not including the antennae. They gradually taper backward and are attached at base between the supra-anal lobe and the sub-anal lobes. The number of segments is not constant and is about thirty-one in each. The basal segment is large and the following segments gradually increase in length to the tip, each with a whorl of bristles around its distal end.

---

[9] In N. venosa it is broadly rounded out behind to conceal the anterior half of the eighth sternite, while in N. sinuata it is merely enlarged but not produced backward at all.

[10] In N. venosa they are entirely exposed and the eighth sternite is provided with scattered chitinous patches. In N. sinuata they are also exposed and they form together a crescent-shaped chitinous area on the eighth sternite.

[11] In N. venosa the ninth sternite is triangularly produced forward to reach the posterior margin of the vaginal valves and to conceal the posterior half of the eighth sternite. The black spots are wanting. In N. sinuata it is rounded out in front to be slightly overlapped by the vaginal valves. The black spots are also wanting.

4. The Development of the Genitalia.

During the first eight instars, the sexes of the naiads can not be distinguished by external characters. Later on, the genital parts of the adult can be seen to develop gradually beneath the semi-transparent skin of the naiad.

*The Male.* Beginning with the ninth instar, a median invagination takes place in the male between the ninth and the tenth sternites, and it continues to develop inward and forward to form the ejaculatory duct. In the fourteenth instar, the supra-anal lobe begins to develop from the posterior border of the tenth tergite, and the supra-anal process gradually recurves upward and forward to lie in the mid-dorsal groove beneath the skin. By the nineteenth instar the ninth sternite is angulately produced backward on the meson to project slightly beyond the posterior margin of the tenth sternite. In the last or the twenty-second instar, the flask-shaped copulatory hooks are seen to form inside of the triangular sub-anal lobes. A small median white lobe begins to form beneath the skin at the anterior border of the ninth sternite. In histological sections, this lobe is seen to develop from an evagination of the body wall, being in no way connected with any of the internal organs. On the posterior margin of the ninth sternite the developing sub-genital plate is seen to be folded beneath the skin with the penis at the tip. Immediately after the adult emerges the supra-anal process becomes free and extends in an upward and backward direction from the supra-anal lobe. The copulatory hooks and the small median white lobe are also set free, and the sub-genital plate stretches backward considerably to bend upward in almost a right angle.

*The Female.* In the female also in the ninth instar, a median invagination takes place between the seventh and eighth sternites to develop gradually into the vagina. In the twentieth instar, the vaginal valves are formed beneath the skin of the eighth sternite to guard the opening of the invaginated vagina. The seventh sternite is merely rounded out posteriorly, but as soon as the adult emerges, it stretches back considerably to form the triangular sub-genital plate, that conceals the eighth sternite.

# PART II. INTERNAL ANATOMY

The internal structures of Plecoptera have been thus far very little studied, Perla being practically the only genus that has been investigated. During the progress of this work, the writer has studied in detail the internal organs of Nemoura vallicularia, and the results are checked up with those of the other two local species. Nine systems of organs within the body have been worked out and the descriptions of them are herewith presented in the following order:

1. Skeletal System.
2. Secretory System.
3. Nervous System.
4. Circulatory System.
5. Digestive System.
6. Excretory System.
7. Muscular System.
8. Respiratory System.
9. Reproductive System.

In preparing the specimens for study, various fixing agents were used and the Diedrich's solution was found to give the most satisfactory results in fixing the organs and tissues both for gross dissection and for histological sectioning.

## SKELETAL SYSTEM (Figs. 62 to 68).

The endoskeleton consists of chitinized tendons of muscles and invaginations of the body wall. Of the former, five pairs are present: two pairs extending from the caudo-lateral borders of the mandibles backward into the head capsule, serving as attachment of the mandibular muscles (Figs. 13, 14, 91, 95); and three pairs in the legs at the junctions between the coxae and trochanter, serving as attachment of the scuto-trochanteral muscles (Figs. 90, 93, 95).

As to the invaginations of the body wall, there are the tentorium in the head and the phragmas, lateral apodemes and furcae in the thorax. The *tentorium, tent,* is composed of three pairs of arms or apodemes: (1) the *anterior arms, aa,* invaginated from between the front and the clypeus; (2) the *dorsal arms, da,* invaginated from the front at the frontal sutures; and (3) the *posterior arms, pa,* invaginated from the maxillary segment above its articulation. The invaginated tips of these arms expand and coalesce to form a plate, the *body of the tentorium, bt,* between the supra-oesophageal ganglion and the oesophagus. The posterior arms fuse with the ventral borders of the epicranium to form the *occipital foramen, ocp,* through which the alimentary canal passes into the thorax.

Invaginations from the thoracic tergites are called the *phragmas, ph.;* those from the pleurites are called the *lateral apodemes, la.;* and those from the sternites are called the *furcae, f.* Of the three phragmas, one is found on the

anterior border of the meso-tergite, another on the anterior border of the meta-tergite, and a third one on the posterior border of the meta-tergite. Three pairs of lateral apodemes are present on the posterior borders of the episternum. The first pair in the prothorax is very small and triangular in shape, each being invaginated from an external pit on the episternum near its posterior border. A furca is a bifid invagination from the furcal pit at the caudo-median part of each sternite. There exists a fourth one in the conjunctiva between the prothoracic and mesothoracic sternites, and it has been called the *post-profurca, ppf,* by Berlese.

All the endoskeletal structures can be studied very easily by dissecting the specimens that are boiled a few minutes in caustic potash. The paper by Comstock and Kochi (1902) on the skeleton of the head of insects was found to be extremely useful.

## SECRETORY SYSTEM (Figs. 69, 70).

There are present in the thorax two pairs of *salivary glands.* The first pair is located in the cephalo-lateral portions of the prothorax, a little above and on the sides of the alimentary canal. The second pair is located in the cephalo-lateral portions of the mesothorax, a little below and also on the sides of the alimentary canal. On each side, a duct runs forward and upward from the mesothoracic gland to the prothoracic gland, and thence forward and downward half way around the alimentary canal to unite with its fellow into a short median duct that opens on the posterior border of the hypopharynx. This duct dilates twice between the glands and again twice between the prothoracic gland and its union with its fellow. Each gland is composed of many glandular cells with distinct nuclei.

Dissections are made of specimens that are fixed in warm Diedrich's solution and preserved in 80% alcohol. A little 0.1% eosin will help to bring out the glands and the ducts which lie closely against the sides of the alimentary canal. The histological sections, that are stained with methylene blue and eosin, show the cell structures very distinctly. The salivary glands of Perla maxima were described by Imhof in 1881.

## NERVOUS SYSTEM (Figs. 71 to 76).

The description of the central nervous system of Perla by Imhof (1881) is only of historical interest in the literature of the order Plecoptera. For this work, the best references are found in the papers by Packard (1880), Hammar (1908) and Holste (1910), and for the histological structures of the brain, the most adequate information is obtained from the papers by Newton (1879), Packard (1880), Viallanes (1884-1887), V. Alten (1910) and Kühnle (1913).

*Methods.* The complete nervous system is dissected out in water immediately after the specimen is killed with potassium cyanide. The results thus obtained are checked up with the specimens that are fixed in Diedrich's solu-

tion, split into dorso-ventral halves, and stained in toto with 0.1% eosin. For histological work, both Gilson's and Diedrich's give good results in fixation, and both methylene blue and Delafield's Haematoxylin are used with equal advantage when counterstained with eosin.

## A. The Central Nervous System (Figs. 71, 72, 76).

### 1. The Supra-oesophageal Ganglion and its Nerves (Figs. 71, 72).

The *supra-oesophageal ganglion* or the brain is situated transversely in the anterior portion of the head, with its front margin immediately caudad of the fronto-clypeal suture. The ganglion consists of two hemispheres that are closely united on the meson. Each hemisphere gives off laterad an *optic nerve,* which enlarges to form the optic lobe and continues laterad to innervate the large compound eye. Anteriorly, each hemisphere sends out three nerves: (1) the *antennal nerve,* arising from the cephalo-lateral border of the hemisphere and extending cephalo-laterad to innervate the antenna; (2) the *clypeo-labral nerve,* arising from the cephalo-dorsal border of the hemisphere and extending directly cephalad to innervate the clypeus and the labrum; (3) the *crus-cerebri,* arising from the cephalo-ventral border of the hemisphere below the base of the clypeo-labral nerve, and extending caudo-ventrad half way around the oesophagus to join the sub-oesophageal ganglion on its anterior border. The *sub-oesophageal commissure* or the oesophageal ring encircles the ventral half of the oesophagus with its both ends connected with the cephalo-ventral borders of the brain at the base of the crura cerberi. From the dorsal surface of the supra-oesophageal ganglion, three small and short *ocellar nerves* extend directly dorsad to innervate the three ocelli.

### 2. The Sub-oesophageal Ganglion and its Nerves (Fig. 75).

The sub-oesophageal ganglion is situated below the oesophagus and the body of tentorium, and is connected with the supra-oesophageal ganglion by the pair of crura-cerebri. It gives off three pairs of nerves: (1) the *mandibular nerves,* arising from its cephalo-lateral borders and extending cephalo-dorsad along the sides of the oesophagus to the mandibles; (2) the *maxillary nerves,* arising from its lateral borders and extending cephalo-laterad to the maxillae; (3) the *labial nerves,* arising from its caudo-lateral borders and extending more or less directly cephalad to the labium. Posteriorly the sub-oesophageal ganglion is connected with the prothoracic ganglion by a pair of longitudinal nerves, the *ventral connectives.*

### 3. The Thoracic Ganglia and Their Nerves (Fig. 76).

There are three large ganglia in the thorax, each composed of two hemispheres, situated on the ventral side of the corresponding segment and connected with the one in front and the one behind by the paired ventral connectives.

With slight variations in the first one (the prothoracic ganglion), they have similar shape and number of nerves. The second one in the series or the mesothoracic ganglion is here described in detail to illustrate the general condition that prevails in the other segments. The differences found in the prothoracic ganglion are noted during the course of discussion. The terminology used by Holste is herewith adopted.

*The Meso-thoracic Ganglion.* It is situated on the ventral side of the segment in front of the furca and the coxal insertions. It is large, dorso-ventrally compressed, slightly wider than long, and angulate in shape, being between hexagonal and octagonal in outline. Anteriorly and posteriorly it is connected with the other ganglia by the paired ventral connectives. The connectives in front give off laterad two pairs of nerves, the anterior and the posterior pairs of *commissural nerves, cmn* (ventral connective nerves, according to Hammar). From the cephalo-lateral borders of the ganglion, a pair of nerves arises, extending first cephalo-laterad and then cephalo-dorsad to innervate the pleural and dorso-ventral muscles on the sides of the segment. These are the *alar nerves, aln,* and are absent in the prothorax. In mesothorax and metathorax where they are present, they become united with the posterior pair of commissural nerves on their way forward and upward to the muscles. From each caudo-lateral border of the ganglion, a nerve extends caudo-laterad into the coxa and thence into the leg. This was called the "Nervus ischiadicus" (ischiatic nerve) by Holste and is here called the *crural nerve, crn* (according to Binet). From each lateral border of the ganglion between the alar and the crural nerves, three slender nerves extend laterad to the muscles. Beginning with the one in front, they are: (1) *the anterior coxal nerve, acn,* (2) *the inferior coxal nerve, icn,* and (3) *the posterior coxal nerve, pcn.* From the posterior border of the ganglion near the base of the crural nerve on each side, a slender nerve extends caudo-laterad to the region of the coxa and breaks down into many smaller branches. This is the *trochanter-extensor nerve, texn.*

4. The Abdominal Ganglia and Their Nerves (Fig. 75).

There exist only five abdominal ganglia which are slightly cephalized to lie in the ventro-median portion of the first four abdominal segments. They are connected with each other and also with the mesothoracic ganglion by very short ventral connectives. The first and the fifth ganglia are comparatively larger in size and each sends caudo-laterad three pairs of nerves. The other three (second, third and fourth) ganglia are smaller and each gives off only one pair of nerves. The first eight pairs of nerves innervate the first eight abdominal segments respectively, while the last pair of nerves innervates the remaining segments.

### B. The Sympathetic Nervous System (Figs. 71, 72).

#### 1. The Dorsal Sympathetic Nervous System.

From the base of the clypeo-labral nerves, a pair of short slender nerves extend mesad to join a small triangular ganglion, which has its apex directed backward and is situated on the dorso-median line of the oesophagus immediately in front of the supra-oesophageal ganglion. These nerves have been called the *arched nerves, arn,* and the small ganglion is called the *frontal ganglion, fg.* From this frontal ganglion a *frontal nerve, fn,* goes directly cephalad into the clypeus; a pair of *pharyngeal nerves, phn,* extend caudo-laterad and then ventrad to the sides of the oesophagus; and a *recurrent nerve, rn,* passes caudad between the supra-oesophageal ganglion and the oesophagus to join the vagus ganglion. The *vagus ganglion, vg,* is also triangular in shape with its apex pointing forward and is situated also on the dorso-median line of the oesophagus immediately behind the supra-oesophageal ganglion. From its caudo-lateral borders, a pair of *stomogastric nerves, st,* extend caudo-laterad and then caudad to the sides of the stomodeum.

#### 2. The Lateral Sympathetic Nervous System.

On each side of the oesophagus, there is an extremely small *lateral ganglion, lg,* which is connected by *lateral nerves, ln,* with the ventro-lateral border of the supra-oesophageal ganglion and with the lateral border of the vagus ganglion.

### C. Histology of the Supra-oesophageal Ganglion (Figs. 73 to 75).

The supra-oesophageal ganglion is completely surrounded by a thin membrane, the *neurilemma, nlem,* and is composed of two kinds of cellular elements: the *ganglionic cells, gc,* and the *medullary substance.* Fundamentally it consists of three principal divisions: the protocerebrum, the deutocerebrum and the tritocerebrum, each of which is derived from one of the segments of the head, and is made up of a pair of primary ganglia, one in each hemisphere.

#### 1. The Protocerebrum.

A small reniform *central body, cb,* lies transversely right at the center of the supra-oesophageal ganglion. It is made up of dense medullary fibers and is indistinctly laminated.

On the sides of the central body, there is a pair of *mushroom bodies* each of which consists of a cup, a stalk, an anterior root and an inner root. The *calyx, cal,* or the cup is here represented in a rudimentary condition by a closer gathering of the ganglionic cells on the posterior border of each hemisphere. The *peduncle, ped,* or the stalk extends forward from the calyx to the side of the central body where it joins its two roots. The *cauliculus, caul,* or the anterior root extends directly forward for a short distance and ends abruptly (Fig. 74).

The *trabacula, trab,* or the inner root extends mesad in front of the central body to nearly abut against its fellow on the meson. The peduncle, the cauliculus and the trabacula are all made up of medullary fibers.

All three of them are embedded in a larger mass of medullary substance, the *protocerebral lobe, prtl,* which is connected with its fellow by a *protocerebral bridge, prtb,* behind the central body. In front of the protocerebral lobe, there is a small rounded *lateral lobe, ll,* which is connected with its fellow by a slender transverse *median lobe, ml,* in front of the trabaculae. The *ocellar nerves* arise from the *ocellar tubercles,* one in front and two behind the central body.

Caudo-laterally each protocerebral lobe continues into the large *optic lobe* which goes to innervate the compound eye and may be distinguished into several distinct layers. Starting from the protocerebral lobe outward, the sequence of the different layers (according to the terminology of Viallances) is as follows: (1) the *terminal medullary mass, tm,* (2) *inner medullary mass, mi,* (3) *inner chiasma, chi,* (4) *outer medullary mass, me,* (5) *outer chiasma, che,* (6) *ganglionic plate, gp,* and (7) *post-retinal fibers, prf.* In the chiasma, the characteristic crossing of fibers is very distinct. The outer medullary mass is very large and may be distinguished into three subdivisions. The ganglionic plate is small and its subdivisions are not recognizable. The post-retinal fibers extend from the ganglionic plate directly to the basement membrane (limitante interne, according to Viallanes) of the compound eye.

In the compound eye, the following layers are recognized: (1) *the basement membrane, bm,* (2) *the retinula layer, ret,* (3) *crystalline-cone layer, crc,* and (4) *the cornea, cor.*

2. The Deutocerebrum (Fig. 74).

The deutocerebrum is a small oval mass of medullary substance, situated in front of the protocerebrum in the cephalo-dorsal portion of each hemisphere. It contains the globular bodies of dense medullary substance, the *glomerulae, gl.* It sends out the nerve to innervate the antenna.

3. The Tritocerebrum (Fig. 74).

Below the deutocerebrum in the cephalo-ventral portion of each hemisphere there exists the tritocerebrum, composed of medullary granules and fibers. It sends out the clypeo-labral nerve, the crus cerebri, the sub-oesophageal commissure and the lateral nerve of the lateral sympathetic system.

## CIRCULATORY SYSTEM (Fig. 77).

The *dorsal vessel* of the circulatory system is situated on the median line, in the dorsal part of the body cavity, between the muscular layer and the alimentary canal. It extends from the ventral surface of the supra-oesophageal ganglion backward to the ninth abdominal segment. Its anterior portion, that lies in the head and thorax, is the *aorta,* which is a simple tube opening anteriorly

below the supra-oesophageal ganglion and continuing backward into the heart in the abdomen. The *heart* is divided into nine *chambers* by constrictions and is provided with nine pairs of triangular muscles, the *wings of the heart*. The lateral margins of these wings are attached to the conjunctiva between segments, from between the first and second segments to between the ninth and tenth. In histological sections, it is found that at each constriction a forwardly directed *valve* is formed on the inside by the folding of the wall, and that *ostia* are present on the sides of the valves, serving as passages for the influx of the blood. In young naiads immediately after molting, the peristaltic pulsation of the heart can easily be observed through the semi-transparent skin.

To study the heart and its wings by gross dissection, specimens are fixed in warm Diedrich's solution, split into dorso-ventral halves and stained in toto in 0.1% eosin or Delafield's haematoxylin after the other tissues are carefully removed. In working with fresh specimens immediately after killing, the heart with its wings can be completely dissected out in water for study, but the disadvantage lies in the dislocation of the attachment of the wings.

## DIGESTIVE SYSTEM (Figs. 78 to 88).

The alimentary canal of Perla has been described by Imhof (1881) and Schoenemund (1912), but for this work the most helpful informations are obtained from the papers by Noyes (1915) and Branch (1920 Thesis).

*Methods.* For gross dissections specimens are fixed in Diedrich's solution. The alimentary canal, being thoroughly fixed and slightly hardened, can be dissected out in its perfectly natural form. For histological work, Bouin's, Flemming's, Gilson's and Diedrich's have been used, and the first two mentioned are found to be very poor in penetration. The hot Gilson's fixes the structures fairly well and takes the methylene blue and eosin very readily, but it fails to fix the mesenteron which is enclosed by the heavy thoracic muscles. The warm Diedrich's solution produces the most satisfactory results. It fixes all parts of the alimentary canal equally and hardens them slightly to prevent any distortion within the body cavity. Specimens fixed in it may be stained either with methylene blue and eosin or with Delafield's haematoxylin and eosin. The former combination gives a better contrast while the latter stains the cellular structures more sharply and is therefore preferred.

### A. General Description (Fig. 78).

The alimentary canal of Nemoura is almost a straight tube in the body cavity, extending throughout the length of the body from end to end. It may be distinguished into three principal divisions: the stomodeum, the mesenteron, and the proctodeum.

1. The Stomodeum.

The stomodeum or the fore-intestine is short and consists of the buccal cavity, the oesophagus and the proventriculus. The *buccal cavity* is surrounded by the mouth parts in the anterior half of the head capsule, and is heavily lined with chitin. It opens backward into the oesophagus and is attached by three pairs of *pharyngeal muscles* to the epicranium above and to the dorsal and posterior arms of the tentorium on the sides and below. The *oesophagus* passes backward as a slender tube between the supra-oesophageal ganglion and the body of the tentorium. When it reaches the posterior margin of the head, it gradually enlarges to form the *proventriculus.* In the anterior part of the prothorax, the proventriculus is succeeded by the mesenteron and is separated from it by a slight constriction, which marks the presence of an oesophageal valve on the inside. The surface of the stomodeum presents a silvery white appearance, which is caused by the circular muscles around it.

2. The Mesenteron.

The mesenteron or the mid-intestine extends backwards from the anterior part of the prothorax to the posterior margin of the fourth abdominal segment, where it is separated from the proctodeum by the insertion of the Malpighian tubules. It is the largest division of the alimentary canal and it fills up the whole body cavity in the thorax, with a diameter one-third that of the thorax. At the posterior margin of the metathorax it begins to narrow down gradually, and when it reaches the fourth abdominal segment, it is only one-fourth as wide as its large anterior portion in the thorax. Thirty-six Malpighian tubules are inserted around its junction with the proctodeum that follows. It is creamy white or light yellow in color and somewhat granular in appearance. Scattered longitudinal and circular muscles can be brought out distinctly by staining it in toto in 1% eosin. In a specimen gorged with food, the peritrophic membrane enclosing the food shows up clearly as a smaller black tube in the mesenteron.

3. The Proctodeum.

The proctodeum or the hind intestine constitutes the remaining portion of the alimentary canal in the rest of the abdominal segments and is composed of the small intestine, the large intestine and the rectum. Behind the malpighian tubules, the *ilcum* or the small intestine succeeds the narrow posterior portion of the mesenteron, and it becomes only a little smaller as it proceeds backward. In segment six it gradually enlarges and continues into the *colon* or the large intestine, which extends to about the middle of segment eight with a diameter twice that of the small intestine. Beginning with the posterior margin of segment eight the large intestine gradually narrows down to form the *rectum,* which opens to the exterior through the T-shaped anus between the supra-anal lobe and the sub-anal lobes. The subdivisions of the proctodeum continue one into the other without any noticeable constrictions. From the rectum two circular

rows of muscles radiate out to the body wall, each row consisting of six longitudinally arranged wing-like muscles. In the anterior row these muscles are attached to the body wall between the eighth and the ninth segments and in the posterior row they are attached between the ninth and the tenth segments. These are the ***radial rectal muscles, rrm*** (Figs. 78, 87).

### B. Histology of the Alimentary Canal (Figs. 79 to 88).

In Nemoura, the cellular structure and musculature of the alimentary canal resemble very closely those of the Trichoptera described by Branch in 1920. In the following discussion, the divisions and subdivisions of the canal are taken up by order beginning from the anterior end.

*The Oesophagus* (Fig. 79). The cells of the epithelium are cubical and the whole epithelium is thrown into six longitudinal folds, being lined with a chitinous intima and supported by a basement membrane. Together with a few longitudinal muscles this wall of the oesophagus is enclosed by a thick layer of circular muscles on the outside.

*The Proventriculus* (Fig. 80). The wall of the proventriculus is thrown into twelve longitudinal folds, six large and six small ones. The intima becomes thickened and forms the stomachic teeth. The epithelial cells are greatly flattened and the epithelium slightly follows the twelve folds in a wavy outline. Instead of lying inside of the circular muscles, a layer of scattered longitudinal muscles lies outside of them.

*The Oesophageal Valve* (Fig. 81). The oesophageal valve is a double structure. It consists of a circular invagination of the thick intima into the posterior part of the proventriculus, and a complete circular fold formed by the projection of the proventriculus into the mesenteron. The inner part of the fold is composed of cubical cells with thick intima, while in the outer part of the fold the cells are flattened and the intima becomes extremely thin. At the point where the outer part of the fold ends, the peritropic membrane arises and the wall begins abruptly with columnar cells and the striated border. The arrangement of the muscular layers is similar to that in the proventriculus.

*The Mesenteron* (Fig. 82). In the mesenteron the cells of the digestive epithelium are columnar in structure. On the inside, the intima is wanting and the epithelium is lined with a striated border. The basement membrane that supports the epithelium is distinct and sinuate. Immediately outside of the basement membrane there is a thin layer of circular muscles and outside of which there is a layer of scattered longitudinal muscles. The peritropic membrane forms a small tube to inclose the food, and is freely suspended in the mesenteron.

*Transition from the Mesenteron to the Proctodeum* (Fig. 83). Immediately in front of the malpighian tubules in the fourth abdominal segment, the columnar cells of the mesenteron and the striated border come to an abrupt end. At a little distance backward the ileum or the small intestine begins suddenly

with cubical cells, covered by an intima which continues into the conducting tubes of the Malpighian tubules. The Malpighian tubules thus open directly into the alimentary canal through the narrow break between the epithelium of the mesenteron and that of the ileum.

*The Ileum* (Fig. 84). The epithelium of the small intestine is thrown into six very deep longitudinal folds, and is composed of cubical cells, lined with an intima. The wall thus formed is immediately surrounded by a thin layer of circular muscles. Outside of this, a thick layer of circular muscles arises to push out some of the longitudinal muscles and enclose the others. The small intestine is then surrounded by four layers of muscles: the ental circular, the ental longitudinal, the ectal circular, and the ectal longitudinal. The ental longitudinal muscles are few and small, while the ectal longitudinal muscles are large and arranged in six rows. At the posterior end of the small intestine in the sixth abdominal segment, all except the ental circular muscles cease to exist.

*The Colon* (Figs. 85, 88). Beginning with the seventh abdominal segment, the cubical cells of the epithelium gradually change into large glandular cells with large nuclei and the epithelium is thrown into six pairs of longitudinal folds with low altitude. This is now the wall of the colon or large intestine, being lined with an intima and immediately surrounded by a thin layer of circular muscles. Six pairs of longitudinal muscles arise and lie on the outside of these circular muscles.

*The Rectum* (Figs. 86, 88). On the posterior border of segment eight, the large cells come to a sudden end and the rectum begins abruptly with columnar cells. The epithelium is thrown into six longitudinal rectal folds, and is lined with an intima. The arrangement of muscular layers is similar to that in the large intestine. In segments nine and ten, two rows of radial rectal muscles extend out from the rectum to the body wall.

*The Anus* (Fig. 87). As the rectum proceeds backward, the six pairs of longitudinal muscles break up into scattered longitudinal muscles; the layer of circular muscles becomes thicker and thicker; the epithelial cells change into cubical structure; and three of the rectal folds are gradually reduced to form the T-shaped anus, which is bounded by the supra-anal lobe above and by the subanal lobes on the sides.

## EXCRETORY SYSTEM (Figs. 83, 89).

The excretory system consists of thirty-six *Malpighian tubules,* which open into the alimentary canal in a circle around the junction between the mesenteron and proctodeum in the fourth abdominal segment. They are long and slender cylindrical tubes, being yellowish-brown in color and almost uniform in diameter throughout the length. Some of them are directed forward reaching as far as the posterior border of the mesothorax, while others are directed backward extending to the anal region in the last segment. They run back and forth

irregularly in a twisting course and become entangled with the tracheae, nerves, adipose tissues and reproductive organs. They are formed from the evaginations of the proctodeum and are composed of three layers: the peritoneal membrane on the outside, the intima lining on the inside, being continuous with that of the proctodeum; and the large cells between the two, forming the thick wall of the tube. Each cell has a large and distinct nucleus and the pigment granules are unevenly distributed in the cells, being stained much darker than the nuclei.

To study the exact number of the Malpighian tubes, a dissection of the fresh specimen is necessary. The abdomen is first broken off from the thorax and then the last three or four segments are slightly separated from the rest in front. By pulling the last few segments backward slowly, the posterior section of the alimentary canal is easily drawn out from the anterior segments. The tubules are thus straightened out and are obtained in complete number without being broken or detached.

## MUSCULAR SYSTEM (Figs. 90 to 95).

As far as insectian musculature is concerned, practically nothing has been done in the order Plecoptera. The best references for this work are papers by Voss (1905) on Gryllus, Dürken (1907) on Ephemeridae, and Brauer (1910) on Dytiscus. Berlese, in his "Gli Insetti," gave a very good account of the muscular system by compiling the results of previous workers and those of his own.

Most writers grouped the muscles according to the region and position they occupy in the body, and separated the muscles in the same group by using arbitrary numerical signs. Others named the muscles according to their functions. Since different insects have different numbers of muscles in the corresponding regions of the body, the muscles bearing identical names of different authors are not necessarily homologous to each other. Again, authors differ in their opinion as to the function performed by each muscle, so homologous structures in two insects may be given different names by different authors, or vice versa. These facts have therefore rendered impossible, at least for the present, the homologies of the muscular systems in various orders of insects.

The writer has confined his study to the cephalic and thoracic muscles in N. vallicularia. In the following description, each muscle is named by the sclerites, to which its two ends are attached. When homologous muscles occur in the same insect in two or all three of its thoracic segments, these muscles are given the same name but are distinguished by the letters—a (= prothorax), b (= mesothorax) and c (= metathorax). The writer has not attempted to study the mechanism of the insect in question, so the functions of the muscles are not taken into consideration.

*Methods.* Immediately after molting, the naiads and adults are killed and fixed in hot Diedrich's solution for six hours. They are preserved in 80% alcohol and are studied by three methods: (1) Some of them are carried through

different grades of alcohol up to pure xylol, in which they are studied under the binocular microscope with transmitted light. The general arrangement and the normal positions of the muscles can be best studied in this way. (2) Other specimens are split open into dorso-ventral or lateral halves. Each half is studied separately. All the internal tissues, except the muscles, are carefully removed with a pair of fine needles (minuten nadeln mounted on sticks). The specimen is then stained in one per cent. erythrosin for about two hours. Each muscle is thus distinctly brought out from the others, and the attachment of its two ends can be easily traced with the needles. (3) Still other specimens are sectioned and stained 30 minutes in Delafield's haematoxylin and 10 minutes in 0.5% eosin. The results obtained from gross dissections are then checked up with the histological sections.

In lettering the figures, the muscles are given a series of consecutive numbers beginning from the head back to the last thoracic segment. Each muscle is thus lettered with a numerical sign which merely refers to the correspondingly numbered name of muscle in the description. Each number is also accompanied by the letters, a, b, or c, which indicates the thoracic segment in which the muscle occurs (a, prothorax; b, mesothorax; c, metathorax).

### A. Cephalic Muscles (Figs. 91, 94, 95).

Labral.

1. *Tentorio-labral.* From anterior arm of tentorium to base of labrum.

Antennal.

2. *Anterior Tentorio-antennal.* From body of tentorium to anterior base of antenna.

3. *Posterior Tentorio-antennal.* From body of tentorium to posterior base of antenna.

Mandibular.

4. *Outer Mandibular.* From outer base of mandible to caudo-lateral part of epicranium.

5. *Inner Mandibular.* The largest muscle in the head, from inner base of mandible backward to caudal part of epicranium and also downward to the posterior arm of tentorium.

Maxillary.

6. *Maxillary-occipital.* From maxilla to ventral part of epicranium.

7. *Cardo-tentorial.* From cardo to body of tentorium.

8. *Tentorio-palpial.* From base of maxillary palpus to body of tentorium.

9. *Tentorio-lacinial.* From base of lacinia to body of tentorium.

10. *Cardo-lacinial.* From cardo to base of lacinia.

Hypopharyngeal.

11. *Tentorio-hypopharyngeal.* From lateral portion of hypopharynx to posterior arm of tentorium.

Labial.

12. *Tentorio-labial.* From ligula (glossa and para-glossa) to posterior arm of tentorium.

B. Thoracic Muscles.

Dorsal Longitudinal (Figs. 91, 95).

13. *Interphragmal.* From phragma to phragma. 13a (in prothorax) from dorsal part of occiput to prephragma of mesothorax.

14. *Scuto-phragmal.* From middle of scutum caudo-laterad to phragma.

15. *Scuto-occipital* (only in prothorax, 15a). From middle of scutum to dorsal part of occiput.

Dorso Lateral (Fig. 92, 95).

16. *Prescuto-episternal.* From prescutum to upper part of episternum. 16a (in prothorax) from lateral border of pronotum to episternum.

17. *Scuto-epimeral* (not in prothorax). From lateral border of scutum to epimerum and episternal suture.

Lateral (Figs. 92, 95).

The outer layer of muscles on the side immediately entad of the lateral body wall.

A. Pleural wing muscles (not in prothorax).

18. *Episterno-sternal.* From upper part of episternum ventrad to sternum.

19. *Episterno-coxal.* From upper part of episternum caudo-ventrad to trochantin and anterior border of coxa. In front of and along the episternal suture.

20. *Epimero-coxal.* From upper part of epimerum caudo-ventrad to posterior border of coxa. Behind and along the episternal suture.

B. Pleural cervical muscles (only in prothorax).

21. *Pronoto-jugular* (21a). From lateral border of pronotum cephalo-ventrad to posterior part of jugum.

22. *Furco-occipital* (22a). From profurca cephalo-dorsad to dorsal part of occiput, intersecting 21a (pronoto-jugular).

23. *Inner Pronoto-jugular* (23a). From lateral border of pronotum cephalo-ventrad to anterior border of jugum. Entad of 21a and 22a. (Fig. 93.)

24. *Jugo-occipital* (24a). From posterior part of jugum cephalo-dorsad to dorsal part of occiput, intersecting 23a (inner pronotal-jugular). Entad of 21a and 22a. (Fig. 93.)

Dorso-ventral (Figs. 93, 95).

The inner layer of muscles on the side, entad of the lateral muscles.

25. *Prescuto-sternal.* From prescutum ventrad to sternum.

26. *Anterior Scuto-coxal.* From scutum caudo-ventrad to trochantin and anterior border of coxa.

27. *Posterior Scuto-coxal.* From scutum caudo-ventrad to posterior border of coxa.

28. *Scuto-trochanteral.* From scutum caudo-ventrad to apodeme of trochanter.

29. *Episterno-furcal.* From episternal suture (lateral apodeme) ento-ventrad to furca.

30. *Intersegmental Furco-phragmal.* From furca caudo-dorsad to phragma of next segment.

VENTRAL (Figs. 94, 95).

31. *Longitudinal Interfurcal.* From furca to furca. 31a (in prothorax) from posterior arm of tentorium to profurca.

32. *Accessory Interfurcal* (not in prothorax). Smaller muscles dorsad of 31 (Longitudinal interfurcal). 32b (in mesothorax) from profurca caudo-mesad to mesofurca. 32c (in metathorax) from mesofurca caudo-lateral to meta-furca.

33. *Anterior Furco-coxal.* From anterior part of furca laterad to anterior border of coxa.

34. *Posterior Furco-coxal.* From posterior part of furca laterad to posterior border of the coxa. 34a (in prothorax) from anterior part of postprofurca laterad to posterior border of coxa.

35. *Intersegmental Furco-coxal* (not in prothorax). 35b (in mesothorax) from postprofurca caudo-laterad to anterior border of middle coxa. 35c (in metathorax) from mesofurca caudo-laterad to anterior border of hind coxa.

36. *Jugo-coxal* (only in prothorax, 36a). From jugum on one side caudo-laterad to anterior border of front coxa on the other side, intesecting its fellow in prosternum.

37. *Profurco-postprofurcal* (only in prothorax, 37a). From profurca caudad to postprofurca.

38. *Postprofurco-mesofurcal* (only in mesothorax, 38b). From postprofurca caudo-laterad to mesofurca.

### C. CRURAL MUSCLES (Fig. 90).

39. *Coxo-trochanteral.* From base of coxa to proximal border of trochanter.

40. *Trochantero-femoral.* From proximal border of trochanter to proximal border of femur.

41. *Femoral.* From dorsal part of femur disto-ventrad to ventral part of femur.

42. *Femoro-tarsal.* From distal part of femur through tibia to base of tarsal claw. Slender and tendon-like in tibia.

43. *Tibio-tarsal.* From distal part of tibia to proximal part of first tarsal segment.

## THE RESPIRATORY SYSTEM (Figs. 96 to 106).

*Literature.* The tracheal system of Plecoptera has not been completely studied before. Schoenemund (1912) figured the tracheal system of Perla but he did not attempt to name the tracheae. Chapman's paper on the basal connection of wing tracheae in Peteronarcys (in Comstock's Wings of Insects) and Kennedy's paper (1922) on the tracheal branches in the Naiads of Lestes are most useful in this work. In the following discussion, the names suggested by Chapman and Kennedy are either used or given as synonyms in parenthesis when they can be homologized.

*Methods.* The naiads and adults are collected immediately after molting and are carried through different grades of glycerin, from 10% up to the pure glycerin. All tissues are thus rendered transparent, except the tracheae with air in them which remain opaque in the body. They can be easily studied in their natural position with either transmitted or reflected light under the binocular microscope. To check up the results, fresh specimens are dissected open in water, kept in 10% glycerin and allowed to concentrate by evaporation. Materials thus prepared keep well for at least two or three months. Specimens that are killed and fixed in warm Diedrich's solution and split into dorso-ventral or lateral halves, are also good for this study. The origin and termination of the branches can be traced with a pair of fine needles made of two minuten madeln mounted on sticks.

### A. The Respiratory System of the Adult (Figs. 96 to 100).

The adult breathes air directly with ten pairs of *spiracles, sp*, two in the thorax and eight in the abdomen. In the thorax, the spiracles are situated on the lateral conjunctiva, with the first pair between the prothorax and mesothorax and the second pair between the mesothorax and metathorax. In the first abdominal segment, where the tergite is reduced to a small dorsal sclerite by the lateral insertion of the hind coxae, the spiracles migrate dorsad to the cephalo-lateral borders of the tergite. The remaining seven pairs of abdominal spiracles are situated on the sides and near the anterior margin of the next seven segments. All the spiracles are connected inward by the *spiracular trunks, spt,* with a pair of *longitudinal trunks, lt,* (dorsal longitudinal tracheae, Chapman; dorsal trunk, Kennedy), which extend from the posterior border of the head to the last abdominal segment. These trunks run parallel to each other along the dorso-lateral borders of the alimentary canal.

1. The Cephalic Tracheal Branches.

At the posterior border of the head each longitudinal trunk divides into two branches. The upper branch goes dorso-mesad to unite with its fellow and form a *dorsal cephalic commissure, dcc,* sending out several small tracheae to tracheate the brain in front. Near its base, this upper branch sends a sub-branch laterad to ramify and tracheate the compound eye. The lower branch goes cephalo-laterad to tracheate the antenna. This lower branch gives off three sub-branches. The first or proximal sub-branch goes ventro-mesad to unite with its fellow and form a *ventral cephalic commissure, vcc,* sending out several small tracheae to tracheate the sub-oesophageal ganglion. The next or second sub-branch soon bifurcates to tracheate the labium and maxilla. The third or last sub-branch also bifurcates to tracheate the labrum and mandible.

2. The Thoracic Tracheal Branches.

With a pair of spiracles in front of its pleura and another pair behind, the mesothorax represents the typical arrangement of tracheal branches in a thoracic segment and is herewith described in detail. The differences that have been found in the prothorax and metathorax, are given at the end of the discussion.

(a) *The dorsal branches.* In the anterior part of the segment, there arises from each longitudinal trunk a stout branch, which goes mesad to unite with its fellow and form a *dorsal thoracic commissure, dtc.* This commissure sends backward two or three pairs of tracheae to tracheate the muscles. The pair, nearest to the lateral border of the segment, is very large and ramifies to tracheate both the dorsal and the lateral muscles. Behind this commissure each longitudinal trunk sends mesad two or three other small branches to tracheate the dorsal muscles.

(b) *The latero-ventral branches.* From the anterior spiracular trunk of the segment there go backward two branches. The upper branch goes caudo-ventrad to the leg and is the *anterior stem of the leg trachea, ast,* (as, Chap.; leg trachea, Kenn.). Near its base, it sends a trachea to the anterior base of the wing. This is the *costo-radial trachea, c-r,* (pleural trachea, Kenn.). The lower branch from the anterior spiracular trunk goes downward and backward to the nervous ganglion, and is the *ganglionic trachea, gt.* It sends backward several tracheae to tracheate the lateral and ventral branches.

From the posterior spiracular trunk of the segment there go forward also two branches. The upper branch goes cephalo-dorsad to the posterior base of the wing, and is the *cubito-anal trachea, cu-a,* (anterior latero-tergal trachea, Kenn.). It sends a small trachea forward to tracheate the lateral muscles. The lower branch from the posterior spiracular trunk goes ventrad to join the anterior stem of the leg trachea in the coxa. This is the *posterior stem of the leg trachea, pst,* (ps, Chap.; anterior spiracular connective, Kenn.). It sends a sub-branch

ventro-mesad to tracheate the nervous ganglion. This sub-branch is the *accessory ganglionic trachea, agt.* It sends a small trachea forward to tracheate the lateral muscles.

(c) *Polymorphism in the ventral tracheal branches* (Figs. 98, 99, 100). The two ganglionic tracheae and the two accessory ganglionic tracheae of both sides all go to the nervous ganglion. The prevailing condition in mesothorax is that these tracheae meet and fuse together to form an X-shaped crossing in the sternum (Fig. 98). Of the seventy-eight specimens studied, three specimens show the following variation: the two ganglionic tracheae unite crosswise to form an *antero-ventral thoracic commissure, avtc;* and the two accessory ganglionic tracheae also unite crosswise to form a *postero-ventral thoracic commissure, pvtc,* (Fig. 99). Two other specimens show another variation in that, the ganglionic trachea and the accessory ganglionic trachea of the same side unite lengthwise to form on each side a *ventral thoracic connective, vtc,* (Fig. 100). This is probably homologous to the ventral longitudinal trachea (Chapman) in Pteronarcys, and the sternal trachea (Kennedy) in Lestes.

(d) *The tracheal branches in the metathorax* (Figs. 96 to 98). As tracheation is concerned, the metathorax resembles the mesothorax in every other respect excepting the ventral branches. In the metathoracic sternum, the prevailing condition is the formation of an antero-ventral thoracic commissure and a postero-ventral thoracic commissure, as described in the foregoing paragraph (Fig. 99). Of the seventy-eight specimens studied, two specimens show a variation in the formation of an X-shaped crossing, which is commonly found in the mesosternum and is also described in the foregoing paragraph (Fig. 98 mesothorax).

(e) *The tracheal branches in the prothorax* (Figs. 96 to 98). Owing to the loss of wing bearing character, the modification of sclerites and the absence of spiracles on the anterior border, the arrangement of tracheal branches in the prothorax is very different from what has been described above. On each side there is only one spiracle behind the pleurum. From the spiracular trunk of this spiracle a tracheal branch goes dorso-cephalad and then cephalad to ramify and tracheate the pronotum. This is here called the *pronotal trachea, prntt,* and is probably homologous to the cubito-anal trachea, cu-a (anterior latero-tergal trachea, Kenn.) of the wing-bearing segments. From the longitudinal trunk near the middle of the segment, a tracheal branch goes ventrad to the leg. According to Kennedy, this is homologous to the anterior stem of the leg trachea, ast, (leg trachea, Kennedy) in the other thoracic segments. From near its base a trachea goes ventro-mesad to the nervous ganglion and unites with its fellow to form a commissure. Again according to Kennedy, this trachea is homologous to the ganglionic trachea, gt, of other segments. The commissure, formed by it and its fellow, is then homologous to the antero-ventral thoracic commissure, avtc, which is commonly found in the metasternum and occasionally located in the mesosternum.

(f) *The tracheal branches in the legs* (Figs. 96 to 98). The anterior stem, ast, and the posterior stem, pst, unite in the coxa to form the *leg trachea, lt,* which is soon divided into two branches. The upper branch runs along the dorsal part of the femur, passes through the tibia and ends at the tip of the third tarsal segment. The lower branch runs along the ventral part of the femur and terminates at its distal end.

3. The Abdominal Tracheal Branches (Figs. 96 to 98).

The first eight abdominal segments have similar arrangement of tracheal branches, so one of these segments is herewith described to represent the typical condition that exists in the rest. Special modifications are noted in the course of discussion.

a. *The dorsal abdominal trachea.* On each side, the spiracle is connected inward by a spiracular trunk with the longitudinal trunk, which gives off a prominent trachea to the dorsal part of the segment. This is here called the *dorsal abdominal trachea, dat.* In segments two to five, each dorsal trachea is greatly developed to ramify and tracheate the reproductive organs above the alimentary canal.

b. *The ventral abdominal commissure.* From the spiracular trunk, a tracheal branch extends ventro-mesad to unite with its fellow and form a *ventral abdominal commissure, vac,* near the posterior border of the segment. In segments one to five the commissures send tracheae forward to tracheate the five respective abdominal ganglia, which are cephalized to lie in the first four segments. In segments seven and eight the commissures send tracheae backward to tracheate the reproductive organs below the alimentary canal.

c. *The mesal abdominal trachea.* In segments four to eight from each spiracular trunk, another tracheal branch extends mesad to ramify and tracheate the alimentary canal. This is here called the *mesal abdominal trachea, mat.* In segments four and five, each mesal abdominal trachea extends cephalo-mesad to the mesenteron, in segment six it extends mesad to the small intestine, and in segments seven and eight each extends caudo-mesad to the rectum.

In segment nine the longitudinal trunk sends a dorsal abdominal trachea to the dorsal part of the segment. It also sends a branch cephalo-ventrad to tracheate the reproductive organs below the alimentary canal. This ventral branch has not been homologized with any of the tracheae described above. In segment ten the longitudinal trunk terminates by breaking down into several small tracheae.

B. The Respiratory System of the Naiad (Figs. 101 to 106).

The naiads have exactly the same arrangement of tracheal branches as that described above in the adults. But since the naiads live in water, with closed *spiracles* and non-functional tracheal system, they acquire some secondary or adaptive characters for aquatic respiration. These adaptive characters are separately described as follows.

1. The Tufts of Peripheral Tracheoles (Fig. 101).

In the naiad, part of the respiratory function is performed by tufts of tracheoles, that arise from the tracheal branches in the body and extend outward to lie immediately entad of the thin ventral body wall. These tufts are present in the submentum, the coxae, the ventral side of the femora, and the first eight abdominal sternites. In the abdomen several tufts arise from each ventral abdominal commissure and extend to the posterior margin of the segment. These tufts of peripheral tracheoles do not persist in the adults.

2. The Rectal Blood Gills (Figs. 102, 103).

Besides the above mentioned, the naiad breathes chiefly by means of blood gills in the rectum.[12]

Each naiad, however, has a pair of tracheal gills on the cephalo-lateral borders of the prosternum. These are the *prosternal tracheal gills* that persist in the adult stage as vestiges. Each gill consists of two tufts of hair-like gill-filaments, the number of which varies with species. In N. venosa, each tuft is composed of five to six gill-filaments. In N. sinuata, there are five to six gill-filaments in each outer tuft, and about fifteen in each inner tuft. A gill trachea extends downward to the base of each gill from the longitudinal trunk near the anterior margin of the prothorax. This gill trachea divides into many branches, each of which enters one of the gill-filaments and subdivides into a large number of tracheoles. Loops are formed by these tracheoles in the gill-filament at its distal end. (Figs. 104 to 106.)

*Methods.* The exuviae of the naiad are left in water for a few days and when the proctodeal intima expands, it can be dissected out and studied separately. The molted intima of the gills can be seen attached to the inner surface of the proctodeal intima. To determine the presence or absence of tracheoles, the rectum is everted by applying pressure to the abdomen of the naiad, or the rectum is dissected out and split open longitudinally to expose the gills. The materials are then studied in 10% glycerin. For minute structures and mode of insertion, the rectum is sectioned longitudinally, and stained either in Delafield's haematoxylin and eosin or in methylene blue and eosin. When treated with the latter method the nuclei stain red while the remaining portions stain blue.

[12] Unlike N. vallicularia, the naiads of the two other local species do not possess rectal blood gills. These are formed by the evaginations of the proctodeal intima and are attached to the epithelial cells in the anterior part of the rectum. They extend backward in the rectum as slender cylindrical tubes, tapering but slightly at the tip, but they never project beyond the anus. They are filled with blood, provided with few scattered nuclei and covered with an intima, which is continuous with that of the rectum and is shed with it in each molt. There is absolutely no trace of tracheoles in them even in histological sections, although the rectum is richly furnished with trachea. There are twenty-four of them, found in the naiad as early as the first instar, and completely cast out of the rectum with the proctodeal intima at the time of transformation.

## REPRODUCTIVE SYSTEM (Figs. 107 to 126).

The internal reproductive organs of Nemoura were described only once before by Klapálek (1896) in his paper on the genital appendages of Plecoptera. Imhof (1881) and Schoenemund (1912) have studied different species of Perla, the female organs of which show remarkable resemblance to those of Nemoura. The best reference for the histology of reproductive organs is found in Schroeder's handbook, in which he summarized the results of various authors.

*Methods.* Dissections are made in water immediately after the specimens are killed in chloroform or carbon tetrachloride. The whole reproductive system can be easily dissected out for study, without the danger of breaking. In order to study these organs in their normal positions within the body, specimens are killed and fixed in warm Diedrich's solution and split into dorso-ventral halves. For histological structures, methylene blue or Delafield's haematoxylin gives good results when counterstained with eosin.

### A. The Male Reproductive Organs (Figs. 107 to 110).

The two *testes* consist of twelve separate spindle-shaped *testicular tubes,* that occupy the dorsal portions of the second to seventh abdominal segments. The proximal ends of these tubes meet in segment five to open together into an enlarged sac above. From each caudo-lateral border of the sac, a *vas deferens* extends backward and downward in a meandering course to the side of segment nine, where it bends suddenly to extend forward. In segment eight it begins to enlarge into the *seminal vesicle,* which continues forward to segment five, becomes narrow and bends upward a little to unite with its fellow below the alimentary canal. A single slender median duct results from this union and runs forward to the posterior border of segment one. There it bends downward and continues into the *ejaculatory duct,* which extends directly backward on the floor of the abdomen to the tip of the male sub-genital plate terminating in a chitinized *penis.*

### B. The Female Reproductive Organs (Figs. 111, 112).

The two ovaries consist of a large number (more than one hundred) of separate *ovarian tubes,* which open to the dorsal and lateral sides of the oviducts. The cylindrical oviducts lie parallel to each other in the dorsal portions of the third to sixth abdominal segments, and are united anteriorly to form an inverted U-shaped structure. In the seventh segment, each caudal end of the oviduct becomes smaller and extends downward half way around the alimentary canal, to open opposite to its fellow on the cephalo-lateral wall of the vagina. The *vagina* has thick walls and opens backward to the exterior between the *vaginal valves* on the eighth sternite. The *bursa copulatrix* is a small sac that opens directly backward on the anterior border of the vagina. The *seminal receptacle* or spermatheca is a large thick-walled pocket, lying on the right side of the alimentary canal, and opening downward from the right on the cephalo-lateral border of the vagina.

### C. Development of the Reproductive Organs.

During the first eight instars, the sexes of the naiads can not be separated either externally or internally. In the histological sections of the newly hatched naiads, two small oval-shaped *gonads* are found lying adjacent to each other in the dorso-median portion of the fourth segment. These gonads devolp later into the testes or ovaries.

#### 1. Male (Figs. 113, 114).

Beginning with the ninth instar an invagination takes place between the ninth and tenth sternites of the male to form the ejaculatory duct, and the gonads in the body develop gradually into six pairs of oval-shaped testicular tubes. The proximal ends of these tubes meet together and open into the united anterior ends of the vasa deferentia, which extend backward and downward around the alimentary canal to join the anterior or distal end of the ejaculatory duct in the ninth segment. By the twentieth instar the testicular tubes attain their full size, and the distal end of the ejaculatory duct reaches the posterior border of the eighth sternite. During the twenty-first instar there is a rapid increase in length of the ejaculatory duct, the distal end of which reaches now the second abdominal segment. The vasa deferentia also increase in length and the increased portions are carried forward by the stretching distal end of the ejaculatory duct. In the next and also the last instar, the ejaculatory duct increases quickly in diameter to attain its full size; the united anterior ends of the vasa deferentia dilate to form the sac above the testicular tubes; the forwardly carried portions of the vasa deferentia enlarge into the seminal vesicles; and the chitinized penis begins to form at the proximal or posterior end of the ejaculatory duct. Immediately after the adult emerges, as the subgenital plate stretches backward and bends upward, it carries with it the stretching ejaculatory duct, with the chitinized penis at its tip. The matured spermatids or spermatazoans are dissected out of the testes and seminal vesicles, smeared on slides, stained with 0.1% eosin and studied under the oil emersion objective. Each *spermatazoa* consists of a small body and a slender tapering tail, which is about eight times as long as its body.

#### 2. Female (Figs. 115, 116).

Beginning with the ninth instar, an invagination takes place between the seventh and eighth sternites of the female to form the vagina, and the gonads in the body develop gradually into two cylindrical oviducts, lying adjacent to each other and tapering toward the anterior end. Caudally they become smaller, diverge to the sides and then extend backward and downward around the alimentary canal to join the vagina below. Later the anterior ends of the oviducts unite to form the inverted U-shaped structure, from evaginations of which the ovarian tubes are formed. The ovarian tubes are short and cylindrical, each tapering toward the distal end and containing ten to fourteen developing eggs with distinct

nuclei. The eggs, that are more advanced in development, are found near the proximal end of the tubes, being large and oval-shaped, provided with distinct walls and separated from the adjacent eggs by deeper constrictions of the tubes. The terminal filament and nurse cells are not developed. The bursa copulatrix and seminal receptacle are also formed from the invaginations of the vagina. The development of all the above mentioned structures is extremely slow and gradual.

By the time the adult emerges, the *eggs* are found, each enclosed in an *egg follicle*, in the ovarian tubes at different stages of development. About two weeks later just before oviposition, most eggs pass into the united oviducts, the egg follicles disappear, and almost all the ovarian tubes become completely absorbed. Each egg attains its full size, consists of an indistinct nucleus and many *yolk cells,* and is completely enclosed in a *gelatinous coat.* This gelatinous coat is secreted by the follicular epithelium as no accessory glands are present in the female reproductive system. The oviducts, being greatly distended by the matured eggs in them, fill up the body cavity in the abdomen, with that portion of the alimentary canal completely collapsed.

### D. Histology of the Reproductive Organs.

1. Male (Figs. 117 to 120).

The *testicular tubes* are enclosed in a thin peritoneal envelope and lined with an epithelial layer. The walls of the epithelial cells are indistinct while the nuclei are large and prominent. The spermatazoans are arranged in bundles within the tubes; but the different zones are not recognizable. (Fig. 117.)

The *vasa deferentia* and the *seminal vesicles* are both enclosed in a thick peritoneum composed of connective tissues, and are lined with an epithelial layer, which is thrown into irregular deep folds. The epithelial cells are glandular in structure with large nuclei but no trace of cell walls. (Fig. 118.)

The *ejaculatory duct* consists of a small conducting tube, lined with a layer of glandular epithelial cells. The whole epithelium is thrown into six longitudinal folds, covered with a chitinous intima, supported by a basement membrane, and enclosed in a very thin peritoneal envelope. The duct is then covered on the outside by an unusually thick layer of circular muscles, the thickness of which is about twice the diameter of the duct itself. No trace of longitudinal muscles has been detected. (Fig. 119.)

The ejaculatory duct continues backward into the chitinized *penis* which is borne at the up-turned posterior end of the male subgenital plate. (Fig. 120.)

2. Female (Figs. 121 to 126).

The *ovarian tubes* are lined with a layer of epithelium with a peritoneal envelope on the outside. The cells of this follicular epithelium separate from the peritoneal envelope to form an epithelial sac, completely enclosing the de-

veloping egg. The cells are cubical, with distinct walls and large nuclei. (Figs. 121, 126.)

The epithelium of the *oviducts* is glandular in structure and is thrown into many slight longitudinal folds. On the outside there is a layer of circular muscles, which is about half as thick as the epithelium. (Fig. 122.)

The *bursa copulatrix* and the *seminal receptacle* are both lined with a thick layer of columnar epithelial cells, which have thin walls and small nuclei. (Fig. 123.)

The *vagina* is lined with a chitinous intima on the inside. The epithelium is composed of columnar cells and are thrown into six folds. The ventral fold along the floor is subdivided into many narrow deep folds. Outside of the epithelium there is a layer of circular muscles, which are thin above but unusually thick below. (Fig. 124.)

In a longitudinal vertical section the vagina is seen to be formed directly from an invagination of the body wall. Its epithelial and intima linings are continuous with the hypodermis and cuticula of the body wall. The bursa copulatrix opens into it directly from the front, the seminal receptacle opens into it from the right above and the oviducts open into it from the sides below. (Fig. 125.)

# PART III. ETHOLOGY

Of the three local species, Nemoura vallicularia inhabits the brook that flows through The Glen by the house of Professor J. G. Needham, by whose kind permission the writer has been able to use the place and carry on the breeding experiments during the year 1921-1922.

## A. Methods and Apparatus.

### 1. Locality.

As the water emerges as a spring from beneath a hanging slope, it flows into a small pond whence it is conducted out to a gently sloping bed by a short iron pipe. The pond serves as a reservoir, the water flowing in a constant and permanent stream from the pipe throughout the year. The water flows with fairly constant velocity and is free from all sediment. The gently sloping bed in front of the pipe is therefore an undisturbed and ideal locality for the breeding work.

### 2. Breeding the Naiads.

Ten newly hatched naiads were placed with food, each in a small shell-vial that was filled with water, stopped with a piece of bolting-silk and fastened with a rubber ring. All the vials were put in a shallow enamel tray which was sunk into the bed of the stream just a little below the water level. A piece of stone was laid on top of the vials to prevent them from being washed away. Thus the experiment began in July, 1921.

### 3. Recording the Instars.

Visits were made to this breeding station daily or every other day. Each vial was given a definite number and was carefully examined on every trip. When exuviae were found they were taken out and each preserved in a vial of alcohol, with a label of date and the number of the vial from which it was taken. In this way, all the instars were recorded during the post-embryonic development. In each instar besides the exuviae, other naiads were also collected and preserved for morphological and anatomical studies.

### 4. Maintaining the Normal Conditions.

Each vial was cleaned once in every week and the food material was renewed. The naiads lived on very well under the normal conditions of temperature, oxygen and food supply, besides being absolutely protected from enemies and accidents.

### 5. Collecting the Adults.

In the following February, about a month before the adults were expected to emerge, the brook was thoroughly searched several times and all naiads that had grown up under natural conditions, were collected and reared in screen cages.

These cages were made of fine wire-screen cylinders, (two and one-half inches in diameter and four inches in height) fitted into tin covers at both ends. The cages containing the naiads and food, were partly sunk into the bed of the stream, with half of it above the water level. In the latter part of March, the matured naiads climbed up above the water inside the cages and transformed into adults. By removing the tin cover, the adults were easily collected and the emergence of the adults were often observed with great satisfaction.

6. Observing the Mating.

The adults were kept in rectangular boxes, made of wooden frame-work, much longer and broader than high, with paste-board bottom, wire-screen sides and glass cover on top. These boxes were placed around the water pipe, with the bottom just in contact with the surface of water. Fresh food material was put into the boxes every day, and there again, the adults lived under the normal conditions of temperature, humidity, air supply and food. The boxes were also large enough for the adults to move around in them freely, so sitting by the boxes and watching through the glass, the act of copulation was observed very accurately.

7. Gathering the Eggs.

Blocks of decaying wood were put in the boxes and slightly supported from the bottom with slender sticks. Gelatinous masses of eggs were found deposited on the undersurface of these blocks that were kept moist by the paste-board. These blocks were then submerged in enamel trays and sunk into the bed of the stream below the water level. The surface bearing the eggs was placed downward and slightly supported from the bottom of the tray. A piece of stone was placed on top of the block to keep it from being washed away. The embryonic development within the eggs could well be followed up in this way, although this undertaking has not been attempted on account of the limited time.

## B. Life History.

Twenty-two instars were recorded during the nine months of hemimetabolous development, from the hatching of the naiads on July 2, 1921, to the emergence of the adults on March 29, 1922. Each ecdysis marked the beginning of an instar and the heads of the naiads, collected immediately after the molts, were measured under the binocular microscope with an ocular micrometer. Each division on the micrometer was 160 micra and was taken as a unit of measurement. The ratio of increase in the width of the head between two molts, was found to be 0.95, from which a series of computed widths of head in the instars was made to compare with the actual widths taken from the specimens. The computed widths corresponded very closely with the actual widths and thus confirmed the accuracy of the latter. From the dates on which ecdysis were recorded, it may be generally stated that the lengths of the first seven stadia varied from four to eight days each, those of the eighth to the fourteenth stadia were about

ten days each and those of the fifteenth to the twenty-second stadia were about twenty days each. In the following, all records are represented in a tabulated form, with three columns on the left as actual data and one column on the right as calculated results for comparison.

| | Instars | Dates of Molting | Actual Widths of Head | Computed Widths of Head |
|---|---|---|---|---|
| HATCHING | 1 | July 2 | 2.25 | 2.3 |
| | 2 | 6 | 2.50 | 2.5 |
| | 3 | 11 | 2.66 | 2.7 |
| | 4 | 18 | 2.75 | 2.9 |
| | 5 | 23 | 3.00 | 3.1 |
| | 6 | Aug. 1 | 3.25 | 3.3 |
| | 7 | 8 | 3.50 | 3.6 |
| | 8 | 13 | 4.00 | 3.9 |
| | 9 | 22 | 4.25 | 4.2 |
| | 10 | Sept. 4 | 4.50 | 4.5 |
| | 11 | 12 | 4.75 | 4.8 |
| | 12 | 24 | 5.00 | 5.1 |
| | 13 | Oct. 2 | 5.50 | 5.4 |
| | 14 | 14 | 5.75 | 5.7 |
| | 15 | 23 | 6.00 | 6.0 |
| | 16 | Nov. 11 | 6.50 | 6.4 |
| | 17 | 30 | 6.75 | 6.8 |
| | 18 | Dec. 21 | 7.00 | 7.2 |
| | 19 | Jan. 10 | 7.50 | 7.6 |
| | 20 | 30 | 8.00 | 8.0 |
| | 21 | Feb. 29 | 8.50 | 8.5 |
| | 22 | Mar. 11 | 9.25 | 9.4 |
| | TRANSFORMATION | 29 | 10.00 | 9.9 |

## C. Biology of the Naiads.

### 1. Habits and Habitat.

The naiads hatch during the first half of July, being almost transparent and measuring about a millimeter in length at time of hatching. They inhabit the shallow brooklet where the water carries very little sediment and keeps running throughout the year at moderate velocity, with a depth of one to two inches. They attach themselves to the undersurfaces of submerged leaves, rarely on wood or stones. When the leaves are turned over, they almost always crawl away immediately to hide themselves on the over-turned surfaces.

### 2. Locomotion.

With their proportionately robust bodies, they crawl but slowly in an awkward manner. When thrown into water and freely suspended in it, they swim slowly by wriggling their bodies from side to side and soon allow themselves to sink to the bottom. They can, however, cling steadily on objects with rough surfaces and resist the currents that would easily wash them away if not thus anchored.

### 3. Food.

Before undertaking the breeding experiment, naiads of the preceding generation were dissected and the contents of the digestive tubes were examined.

Besides some fine sediment and the half digested fragments of decaying leaves, there were found great varieties of unicellular algae, chiefly diatoms and desmids. No remains of animal tissue have ever been detected, so the naiads are herbivorous in their food habits. At the beginning of the experiment, the naiads were fed with different kinds of plant tissues that were found in and about the water which they inhabited. The submerged elm leaves were found to be the only thing that constituted their diets. They fed upon the epidermis and tissues, leaving the veins behind and thus completely skeletonizing the leaves (Fig. 127). During the growing period, the first eighteen instars, the amount of food eaten by each per week was at least twenty times its own volume.

4. NATURAL ENEMIES.

Many times it has been observed that the larvae of a Hydrophilid beetle preyed upon the naiads that lived under natural and unprotected conditions. These larvae have often been found together with the naiads of all the local species. A Stratiomyid larva, belonging to the genus Stratiomyia, was once observed to prey on one of the naiads.

5. EPIZOANS AND EPIPHYTES.

Rotifer citrinus, stalked Ciliates and stalked Diatoms have been found attached to the body of the naiads, some of which have been preserved in alcohol with the rotifers still attached to the thorax.

6. QUIESCENT PERIOD.

Beginning approximately with the eighteenth instar there is a gradual decrease in activity. In about the twentieth instar, the amount of food eaten is reduced to almost nothing and the naiads hardly move around even when disturbed. After this climax, they slowly recover their activities and become perfectly normal before transformation. This quiescent period begins and ends so gradually that no distinct lines could be drawn to mark its limits. During this period, the wing pads, the reproductive organs, the large amount of adipose tissue and other internal structures develop as usual without any interruption.

7. ECDYSIS.

At the time of molting, the old skin splits along the dorso-median line of the thorax and along the epicranial suture of the head. The intima that lines the stomodeum, the protodeum, the tracheal trunks and the rectal blood gills, is shed with the cuticula. All the moltings, with the exception of the last one, take place in water.

8. TRANSFORMATION.

Transformations have been recorded only between nine o'clock in the morning and five o'clock in the afternoon. The matured naiad climbs up above the water and attaches itself firmly on a vertical surface, rarely the undersurface,

of any object. By drawing its body forward, the emerging adult ruptures the old cuticula from within. The thorax is first pushed out through the cleft while the head, being held by the old skin, bends back under the thorax with the antennae directed backward between the legs. By pushing itself further upward and forward, the head, the antennae, the legs and the wings are gradually drawn out from the old skin. It then lifts up its head to straighten out the antennae, sets its legs on the exuviae and pulls out the rest of the abdomen. It leaves the cast skin, lights on the surrounding object and moves its head and abdomen up and down slowly as the dark and wrinkled wings smoothen out gradually from the base to the apex. By the time the wings are fully expanded, they are held up vertically on the back, being creamy white in color with faintly indicated veins (Fig. 128). Longitudinal grooves begin to show on the smooth surfaces of the wings, which are then folded down slowly along these corrugations until finally they lie horizontally on the back. Usually it takes about four minutes for the adult to completely emerge after the rupture of the old skin, three minutes for the wings to be fully expanded, and five minutes for them to become folded in position. The adult is now yellowish brown in color with the head and pronotum comparatively darker than the rest of the body. It begins to crawl around and is ready to fly when disturbed. The darkening of the sclerites goes on very slowly and it takes about twelve hours before the adult attains its normal coloration.

The period of transformation extends from the middle of March to the first of May, with the greater majority emerging during the first half of April. Early in the period of transformation, more males are found but later on the condition is reversed and the females become dominant. From the total number of specimens collected during a season, the proportion of sexes shows a higher percentage of females.[18]

### D. Biology of the Adults.

#### 1. Habitat.

The majority of the adults live among the vegetation around the water, although some of them have been found several hundred yards away from the glen. As a rule, they prefer shaded and damp places. Those that are kept in screen boxes usually hide themselves in shaded corners or under the plant leaves near the moist paste-board bottom.

#### 2. Locomotion.

The adults are very inactive early in the morning and late in the afternoon, as well as on cloudy and cold days. At about noon time when it is sunny and warm, they crawl about actively in the boxes and if the glass cover is removed,

[18] In N. venosa, the period of transformation extends from the middle of May to the first of July and in N. sinuata, it extends from the first of June to the end of August. These two species often occur together.

they immediately rush out and fly away. It has been observed that in a single continuous flight, an adult can easily travel a vertical distance of thirty to forty feet or a horizontal distance of about seventy feet. The flight is slow and gentle and the direction of flight usually follows a nearly straight line.

3. Food.

Of the various kinds of living plant leaves found around the water and fed to the adults, the young leaves of Touch-me-not are eaten. The adults feed either from the leaf-margin, gnawing off narrow strips smoothly, or on scattered areas of the leave surface, scraping away only a thin layer of the epidermis, but they never eat through the leaves. They eat but very little and some of the isolated ones have been able to live about a week under absolute starvation.

4. Mating.

About a week after transformation the adults reach the sexual maturity. Mating under captivity has been observed four times between eleven o'clock in the morning and two o'clock in the afternoon. A pair was caught while mating and was preserved so naturally as to show most satisfactorily, the method of copulation and the function of the male genital parts. The pairing adults were allowed to crawl on to a piece of glass which was quickly inverted over a cup of boiling water. They were thus plunged into the killing agent that caused an instantaneous death and fixed the different parts of the bodies in perfectly natural form at the moment of death. The specimens were then transferred into 95% alcohol, in which they have been keeping very nicely in the collection. When examined under the binocular microscope, the male is seen to light upon the back of the female and grasp her in the thorax with his legs. He bends the slightly recurved tip of his abdomen under that of the female and pulls open her subgenital plate with one of the recurved flask-shaped copulatory hooks, the modified sub-anal lobes. The chitinized penis, borne at the tip of his up-turned sub-genital plate, is thus introduced into the vagina between the vaginal valves, and the caudal process of his supra-anal lobe acts as a supporter of the female ninth sternite (see Fig. 129). It is now evident that in this species, N. vallicularia, the male supra-anal process does not act as a sperm conveyor.[14] The fact, that the male sub-genital plate is greatly prolonged and bent upward almost in a right angle, with the chitinized penis at the tip, makes a sperm conveyor unnecessary, and that, the male supra-anal process is directed backward and upward, explains its function as a supporter of the female ninth sternite, (Fig. 129).

[14] This name was given by Walker (1922) to homologous structures in other species of stone-flies. In N. venosa and N. sinuata, the caudal process of the male supra-anal lobe is recurved forward to lie closely above the lobe itself, and the male sub-genital plate is short and not bent upward. There the condition is entirely different and the supra-anal process may actually serve as a sperm conveyor. The writer, however, has not seen the mating of these species and is therefore unable to make any definite statement as to the function of their male supra-anal processes.

5. Oviposition.

After mating, the female lives on for about a week, during which she leads a retiring life, hiding herself in shaded places. Her abdomen is greatly distended by the increasing size of the eggs, which enter the oviduct and each becomes enclosed in a gelatinous coat. Though the act of oviposition has not been observed, yet the eggs have been found in the screen boxes in which the isolated females were kept. The eggs were laid in irregular gelatinous masses on wet decaying wood and leaves of Daisy Flea-bane. These egg-masses are white and almost transparent, each containing 150 to 200 eggs. The eggs are irregularly distributed in the mass and are separated from each other by the gelatinous coat which swells considerably after the eggs are laid.

6. The Length of Adult Life.

Under captivity too many factors come in to bring about the untimely deaths of the adults. It can only be stated in a general way that the males live a little over one week and die soon after mating, while the females live about two weeks and die after oviposition.

# BIBLIOGRAPHY

Of all the references consulted, only the more important ones are listed here.

ALTEN, HANS V. 1910. Zur Phylogenie des Hymenopterengehirns. Jena. Zeits. f. Naturw., 46:511-590.

BANKS, NATHAN. 1907. Catalogue of the Neuropteroid Insects (except Odonata) of the United States. Amer. Ent. Society, 54 pp.

BERLESE, ANTONIO. 1909. Gli Insetti.

BINET, A. 1894. Contribution a l'étude du système nerveux sous-intestinal des Insects. Jr. de l'Anat et de la phys., 30:449-450.

BRANCH, HAZEL ELIZABETH. 1922. A Contribution to the Knowledge of the Internal Anatomy of Trichoptera. Ann. Ent. Soc. Amer., 25:256.

BRANDT, EDUARD. 1880. Vergleichend-anatomische Skizze des Nervensystems der Insekten. Hor. Soc. Ent. Ross., 15:1-101.

BRIGGS, CHARLES ADOLPHUS. 1897. A Curious Habit in Certain Male Perlidae. Ent. Mon. Mag., 33:207-208.

BRAUER, ALBERT. 1909. Die Süsswasserfauna Deutschlands, Heft 8. Plecoptera (by Frank Klapálek).

BRAUER, ALBERT. 1910. Die Muskulatur von Dytiscus Marginalis. Zeits. f. wiss. Zool., 95:594-646.

CHAPMAN, ROYAL NORTON. 1918. The Basal Connections of the Tracheae of the Wings of Insects. (*In* Comstock, J. H., The Wings of Insects.)

COMSTOCK, J. H. 1918. The Wings of Insects.

COMSTOCK, J. H. 1920. An Introduction to Entomology.

COMSTOCK, J. H., and KELLOGG, V. L. 1916. The Elements of Insect Anatomy.

COMSTOCK, J. H., and KOCHI, C. 1902. The Skeleton of the Head of Insects. Amer. Nat., 36:13-45.

CRAMPTON, G. C. 1915. The Thoracic Sclerites and the Systematic Position of Grylloblatta campodeiformis, Walker. Ent. News, 26:337-350.

CRAMPTON, G. C. 1917. A Phylogenetic Study of the Lateral Head, Neck and Prothorax Regions in some Apterygota and Lower Pterygota. Ent. News, 28:398-412.

CRAMPTON, G. C. 1917. A Phylogenetic Study of the Terminal Abdominal Segments and Appendages in some female Apterygotan and Lower Pterygotan Insects. Jr. N. Y. Ent. Soc., 25:225-236.

CRAMPTON, G. C. 1918. A Phylogenetic Study of the Terminal Abdominal Structures and Genitalia of Apterygota, Ephemerid, Odonata, Plecoptera, Neuroptera, Orthoptera and their Allies. Bull. Brook. Ent. Soc., 13:49-68.

CRAMPTON, G. C. 1918. The Thoracic Sclerites of the Grasshopper Dissosteira carolina. Ann. Ent. Soc. Amer., 11:347-370.

CRAMPTON, G. C. 1920. A Comparison of the Genitalia of Male Hymenoptera, Mecoptera, Neuroptera, Diptera, Trichoptera, Lepidoptera, Homoptera and Strepsiptera, with those of Lower Insects. Psyche, 27:34-44.

CRAMPTON, G. C. 1920. Remarks on the Basic Plan of the Terminal Abdominal Structures of the Males of Winged Insects. Can. Ent., 52:178-183.

CRAMPTON, G. C. 1920. Some Anatomical Details of the Remarkable Winged Zorapteron. Proc. Ent. Soc. Wash., 22:98-106.

DEEGENER, P. 1904. Die Entwicklung des Darmcanals der Insecten während der Metamorphose. Zool. Jahrb., 20:499-676; 26:45-182.

DURKEN, BERNHARD. 1907. Die Tracheen-Kiemen Muskulatur der Ephemeriden unter Berücksichtigung der Morphologie der Insektenflügels. Zeits. f. wiss. Zool., 87:435-550.

FLÖGEL, J. H. L. 1878. Ueber den einheitlichen Bau des Gehirns in den verscheidenen Insecten Ordnungen. Zeits. f. wiss. Zool. Bd., 30 suppl., pp. 556-592.

HAGAN, HERMANN AUGUST. 1877. Beiträge zur Kenntniss von Pteronarcys. Ent. Zeitung, 38:477-489.

HAMMAR, A. G. 1908. On the Nervous System of the Larva of Corydalis cornuta L. Ann. Ent. Soc. Amer., 1:105-127.

HEADLEE, THOMAS, J. 1906. Blood Gills of Simulium pictipes. Amer. Nat., 40:875-885.

HENNEGUY, L. 1904. Les Insectes.

HOLSTE, GEORG. 1910. Das Nervensystem von Dytiscus marginalis. Zeits. f. wiss. Zool., 96:419-476.

IMHOF, OTHMAR EMIL. 1881. Beiträge zur Anatomie der Perla maxima Scopoli. Inaug.-dissert.

JANET, CHARLES. 1899. Essai sur la Constitution morphologique de la tête de l'insecte. Paris. Carré et Naud., p. 74.

JONESCU, C. N. 1909. Vergleichende Untersuchungen über das Gehirn der Honigbeine. Jena. Zeits. f. Nat., 45:111-180.

KATHARINER, LUDWIG. 1901. Zur Biologie von Perla maxima Scop. Allg. Zeits. Ent., 6:258-260.

KEMPNY, PETER. 1897. Zur Kenntniss der Plecopteren. I. Ueber Nemura Latr. Verh. K. K. Zool.-bot. Ges., 48:1-32.

KENNEDY, CLARENCE HAMILTON. 1922. The Homologies of the Tracheal Branches in the Respiratory System of Insects. Ohio Jr. of Science.

KENYON, F. C. 1896. The Brain of the Bee. Jr. Comp. Neur., 6:131-210.

KLAPÁLEK, FRANK. 1896. Ueber die Geschlechtsteile der Plecopteren, mit besonderer rücksicht auf die Morphologie der Genitalanhänge. Sitzb. Kais. Akad. Wiss. Math.-Nat. Classe., 105:683-738.

KLAPÁLEK, FRANK. 1909. Plecoptera. (*In* Brauer, A. Die Süsswasserfauna Deutschlands, 8:1-95.)

KRAUSS, W. C. 1884. On the Nervous System of the Head of the Larvae of Corydalis cornuta L. Psyche, 4:179-184.

KÜHNLE. 1913. Untersuchungen über das Gehirn, die Kopfnerven und die Kopfdrüsen des gemeinen Ohrwurms. Jena. Zeits. f. Nat., 50:17-276.

LATEREILLE, CITOYEN. 1796. Précis des caractères generiques des insectes, disposés dans un ordre Naturel.

LAUTERBORN, ROBERT. 1903. Tracheenkiemen an den Binen einer Perliden-Larve (Taeniopteryx nebulosa L.). Zool. Anz., 26:637-642.

LESTAGE, J. A. 1919. Études sur la biologie des Plécoptères, 9:257-268; 10:1-32.

MACLACHLAN, ROBERT. 1865. Notes on the Manner in which the Females of the genus Leuctra Carry their Eggs. Ent. Mon. Mag., 1:216.

MORTON, KENNETH J. 1894. Palearctic Nemourae. Trans. Ent. Soc. London, 42:557-574.

NEEDHAM, JAMES GEORGE. 1897. Digestive Epithelium of Dragonfly Nymphs. Zool. Bull., 1:103-113.

NEWPORT, GEORGE. 1844. On the Existence of Branchiae in the Perfect State of a Neuropterous Insect, Pteronarcys regalis, Newm., and other species of the same genus. Ann. and Mag. Nat. Hist., 13:21-25.

NEWTON, E. T. 1879. On the Brain of the Cockroach, Blatta orientalis. Quart. Jr. of Micros. Science, n. s., 19:340-356.

NOYES, ALICE AYR. 1915. The Proventriculus of a Hydropsyche Larva. Jr. Ent. and Zool., 7:34-44.

PACKARD, ALPHEUS SPRING. 1880. The Brain of the Locust. Second Report U. S. Ent. Commission, pp. 223-242.

PACKARD, ALPHEUS SPRING. 1889. Notes on the Epipharynx and the Epipharyngeal Organs of Taste in Mandibulate Insects. Psyche, 5:139-199; 5:222-228.

PACKARD, ALPHEUS SPRING. 1898. A Text-book of Entomology.

PICTET, FRANÇOIS JULES. 1832. Mémoire sur les Larves Némoures. Ann. Sciences Nat. France, 22:1-24.

PICTET, FRANÇOIS JULES. 1841-1842. Historie naturelle générale et particulière des insects Neuroptères. Première monographie: Famille des Perlides. Geneva.

RIS, FR. 1902. Die Schweizerischen Arten der Perliden-Gattung Nemura. Mitth. Schweiz. Ent. Ges., 10:378-406.

ROUSSEAU, E. 1921. Les Larves et Nymphes des Insectes d'Europe, pp. 274-320.

SCHOENEMUND, EDUARD. 1912. Zur Biologie und Morphologie einiger Perla-arten. Zool. Jahrb. Abt. Anat. u. Ontog., 34:1-56.

SCHRÖDER, C. 1912-1913. Handbuch der Entomologie.

SCHWERMER, WILHELM. 1913-1914. Beiträge zur Biologie und Anatomie von Perla marginata Scopoli. Zool. Jahrb. Abt. Anat. u. Ontog., 37:267-312.

SMITH, LUCY WRIGHT. 1913. The Biology of Perla immarginata Say. Ann. Ent. Soc. Amer., 6:203-212.

SMITH, LUCY WRIGHT. 1917. Studies of North American Plecoptera. Trans. Amer. Ent. Soc., 43:433-490.

SNODGRASS, ROBERT EVANS. 1909. The Thorax of Insects and the Articulation of the Wings. Proc. U. S. National Museum, 36:511-595.

SNODGRASS, ROBERT EVANS. 1910. The Thorax of the Hymenoptera. Proc. U. S. National Museum, 39:37-91.

TAYLOR, LELAND H. 1918. The Thoracic Sclerites of Hemiptera and Heteroptera. Ann. Ent. Soc. Amer., 11:225-254.

VIALLANES, H. 1884-1887. Études histologique et organologique sur les centres nerveux et les organes des sens. Bibl. des Htes Études Sc. Nat., 29(4):1-74, 1884; 31(1):1-34, 31(3):1-34, 1885; 33(2):1-96, 1887; 34(3):1-20, 1887.

VOSS, FRIEDRICH. 1905. Ueber den Thorax von Gryllus domesticus, mit besonderer Berücksichtigung des Flügelgelenks und dessen Bewegung. Zeits. f. wiss. Zool., 78:268-521, 645-759.

WALKER, E. M. 1919. The Terminal Abdominal Structures of Orthopteroid Insects. A phylogenetic study. Ann. Ent. Soc. Amer., 12:267-316.

WALKER, E. M. 1922. The Terminal Structures of Orthopteroid Insects. A phylogenetic Study. Part II. The Terminal Abdominal Structures of the Male. Ann. Ent. Soc. Amer., 25:1-76.

WOODS, WILLIAM COLCORD. 1918. The Alimentary Canal of the larva of Altica bimarginata Say (Coleoptera). Ann. Ent. Soc. Amer., 11:283-318.

# INDEX TO FIGURES

*I*—Prothorax
*II*—Mesothorax
*III*—Metathorax
*1-10*—abdominal segments 1 to 10
*aa*—anterior arm of tentorium
*ab*—abdominal segment
*abg*—abdominal ganglion
*abn*—anterior coxal nerve
*aepm*—anepimerum
*aeps*—anepisternum
*agt*—accessory ganglionic trachea
*aln*—alar nerve
*an*—anus
*anp*—anterior notal process
*ant*—antenna
*antn*—antennal nerve
*ants*—antennal sclerite
*ao*—aorta
*aos*—adanal ossicle
*arn*—arched nerve
*ast*—anterior stem of leg trachea
*avtc*—antero-ventral thoracic commissure

*bc*—bursa copulatrix
*bm*—basement membrane
*bt*—body of tentorium

*c*—costa
*cal*—calyx
*car*—cardo
*caul*—cauliculus
*cb*—central body
*cc*—crus cerebri
*cho*—outer chiasma
*chi*—inner chiasma
*cl*—clypeus
*clln*—clypeo-labral nerve
*cm*—circular muscle
*cmn*—commissural nerve
*col*—colon
*cor*—cornea
*c-r*—costa-radial trachea
*crc*—crystalline cone layer
*crn*—crural nerve
*cs*—coronal suture
*cu*—cubitus
*cu-a*—cubito-anal trachea
*cut*—cuticula
*cx*—coxa

*da*—dorsal arm of tentorium
*dat*—dorsal abdominal trachea
*dcc*—dorsal cephalic commissure
*deut*—deutocerebrum
*dig*—digitus
*dtc*—dorsal thoracic commissure

*e*—compound eye
*eccm*—ectal circular muscle
*eclm*—ectal longitudinal muscle
*egf*—egg follicle
*egn*—egg nucleus
*ejd*—ejaculatory duct
*encm*—ental circular muscle
*enlm*—ental longitudinal muscle
*ep*—epithelium
*epc*—epicranium
*eps*—episternum

*fe*—femur
*fg*—frontal ganglion
*fn*—frontal nerve
*fr*—front
*fs*—frontal suture

*ga*—galea
*gc*—ganglionic cell
*gl*—glossa
*glep*—glandular epithelium
*gp*—ganglionic plate
*gt*—ganglionic trachea

*hphy*—hypopharynx
*hypd*—hypodermis

*icn*—inferior coxa nerve
*il*—ileum
*in*—intima

*js*—jugular sclerite

*kepm*—katepimerum
*keps*—katepisternum

*lac*—lacinia
*legt*—leg trachea
*lg*—lateral ganglion
*li*—labium
*lin*—labial nerve
*ll*—lateral lobe
*lm*—longitudinal muscle
*ln*—lateral nerve

*lp*—labial palpus
*lr*—labrum
*lt*—longitudinal trunk

*m*—media
*mat*—mesal abdominal trachea
*md*—mandible
*mdn*—mandibular nerve
*mds*—mandibular sclerite
*me*—outer medulary mass
*men*—mentum
*meron*—meron
*mes*—mesenteron
*mi*—inner medulary mass
*ml*—median lobe
*mos*—median ossicle
*mpt*—malpighian tubule
*msf*—meso-furca
*mtf*—meta-furca
*mx*—maxilla
*mxn*—maxillary nerve
*mxp*—maxillary palpus
*mxpl*—maxillary pleurite

*n*—nucleus
*nlem*—neurilemma
*nos*—notopleural ossicle

*oc*—ocellus
*od*—oviduct
*oe*—oesophagus
*opl*—optic lobe
*ot*—ovarian tube

*p*—penis
*pa*—posterior arm of tentorium
*pagl*—paraglossa
*pal*—prealare
*palb*—prealar bridge
*pcn*—posterior coxal nerve
*pcp*—pleural coxal process
*ped*—peduncle
*per*—peritoneum
*peps*—pre-episternum
*pf*—profurca
*phm*—pharyngeal muscle
*phn*—pharyngeal nerve
*pm*—peritrophic membrane
*pnp*—posterior notal process
*ppf*—post-profurca
*pph*—pre-phragma
*prf*—post-retinal fiber
*prnt*—pronotum
*prntt*—pronotal trachea
*prov*—proventriculus

*prt*—protocerebrum
*prtb*—protocerebral bridge
*pscl*—post-scutellum
*psct*—post-scutum
*pst*—posterior stem of leg trachea
*ptph*—post-phragma
*pvtc*—postero-ventral thoracic commissure
*pwp*—pleural wing process

*r*—radius
*rect*—rectum
*ret*—retinula layer
*r-m*—radio-median cross vein
*rn*—recurrent nerve
*rrm*—radial rectal muscle

*sal*—subalare
*sald*—salivary duct
*salg*—salivary gland
*sb*—striated border
*sbga*—subgalea
*sbmen*—submentum
*sboec*—suboesophageal commissure
*sboeg*—suboesophageal ganglion
*sc*—subcosta
*scl*—scutellum
*scl*—scutum
*sp*—spiracle
*spm*—spermatazoa
*spoeg*—supra-oesophageal ganglion
*sr*—seminal receptacle
*st*—stomogastric nerve
*stn*—sternum
*stp*—stipes
*sv*—seminal vesicle

*tar*—tarsus
*tc*—tarsal claw
*texn*—trochanter extensor nerve
*thg*—thoracic ganglion
*ti*—tibia
*tm*—terminal medulary mass
*tn*—trochantin
*tr*—trochanter
*trab*—trabacula
*trit*—tritocerebrum
*tt*—testicular tube

*vac*—ventral abdominal commissure
*vag*—vagina
*vc*—ventral connective
*vcc*—ventral cephalic commissure
*vcx*—vera-coxa
*vd*—vas deferens
*vg*—vagus ganglion
*vtc*—ventral thoracic connective
*vv*—vaginal valve

## PLATE I.

### EXTERNAL MORPHOLOGY.

Fig. 1. Dorsal view of the adult (male), with wings spread out to show the dorsal sclerites.

1a. Venation of the right wings of the adult.

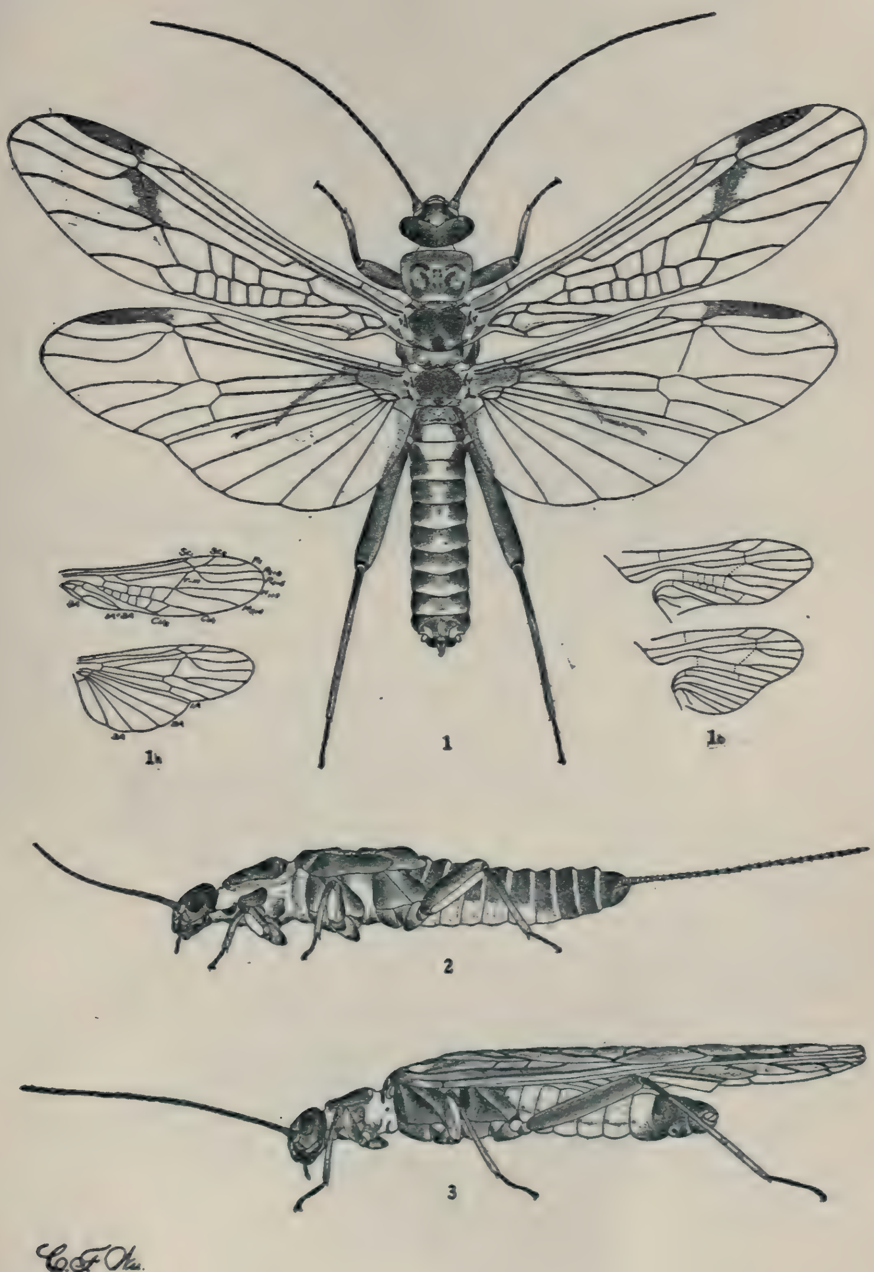
1b. Tracheation of the right wing pads of the naiad.

2. Lateral view of the naiad.

3. Lateral view of the adult (female).

(For lettering of sclerites, see Fig. 8 and explanation.)

# PLATE I



## PLATE II.

Fig. 4. Dorsal view of the adult, with wings folded in natural position.

5. Ventral view of the adult (female).

6. Dorsal view of the naiad.

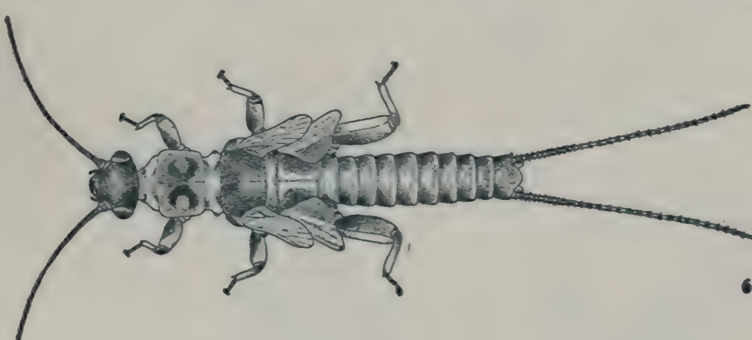
7. Ventral view of the naiad (female).

(For lettering of sclerites, see Fig. 8 and explanation )

PLATE II

4

5



6

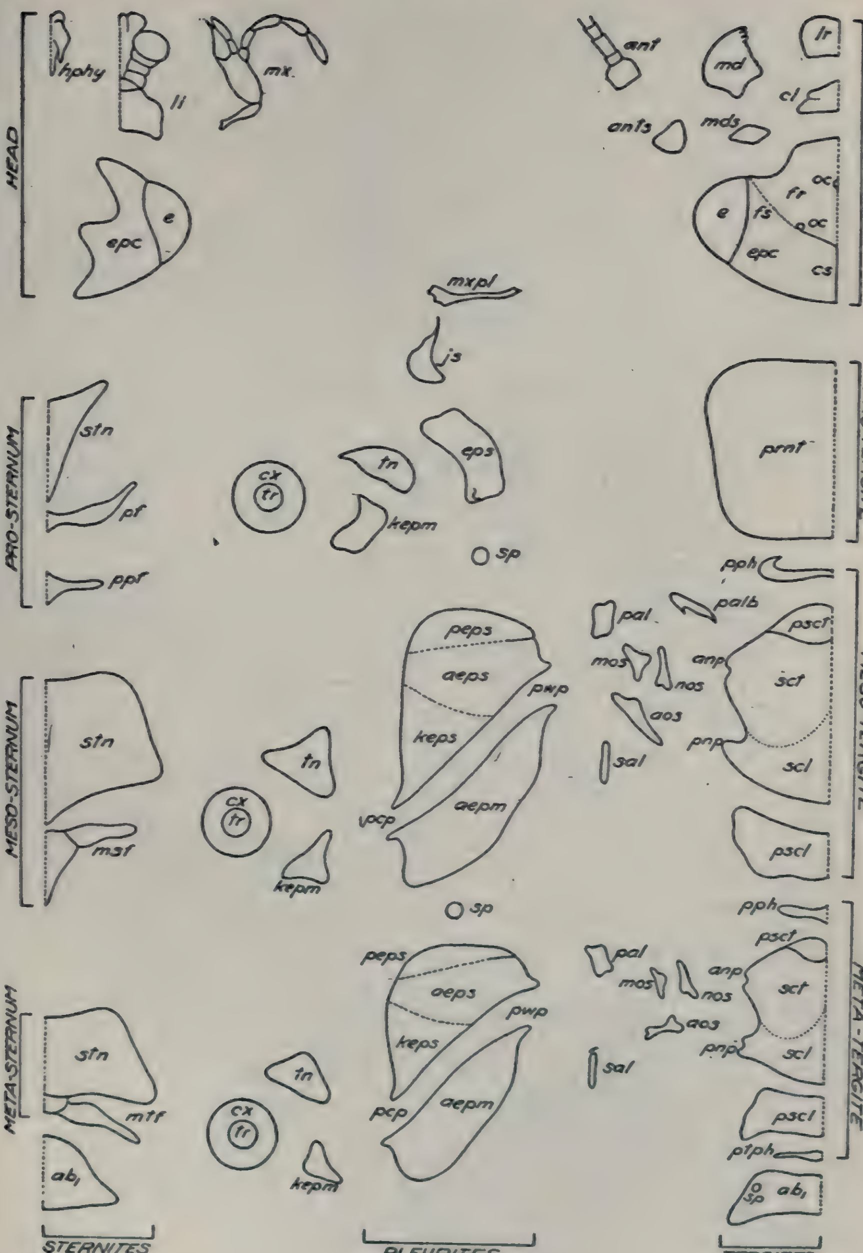
## PLATE III.

Fig. 8. Diagram, showing the cephalic and thoracic sclerites spread out in a ground plan.

### ABBREVIATIONS.

$ab_1$—first abdominal segment
aepm—anepimerum
aeps—anepisternum
anp—anterior notal process
ant—antenna
ants—antennal sclerites
aos—adanal ossicle
cl—clypeus
cs—coronal suture
cx—coxa
e—compound eye
epc—epicranium
eps—episternum
fr—front
fs—frontal suture
hphy—hypopharynx
js—jugular sclerite
kepm—katepimerum
keps—katepisternum
li—labium
lr—labrum
md—mandible
mds—mandibular sclerite
mos—median ossicle
msf—mesofurca
mtf—metafurca
mx—maxilla
mxpl—maxillary pleurite
nos—notopleural ossicle
oc—ocellus
pal—prealare
palb—prealar bridge
pcp—pleural coxal process
peps—pre-episternum
pf—profurca
pnp—posterior notal process
ppf—post-profurca
pph—prephragma
prnt—pronotum
pscl—post-scutellum
psct—prescutum
ptph—postphragma
pwp—pleural wing process
sal—subalare
scl—scutellum
sct—scutum
sp—spiracle
stn—sternum
tn—trochantin
tr—trochanter

PLATE III




8

C. F. Wu.

## PLATE IV.

### APPENDAGES.

Fig. 9. Dorsal view of the labrum (adult).

10. Same (naiad).

11. Ventral view of the labrum (adult) showing sense pit and sense papillae.

12. Same (naiad).

13. Right mandible (adult) showing the mandibular muscles and the chitinized tendons of the muscles.

14. Same (naiad).

15. Right maxilla (adult).

16. Same (naiad).

17. Dorsal view of the hypopharynx (adult).

18. Same (naiad).

19. Lateral view of the hypopharynx (adult).

20. Same (naiad).

21. Ventral view of the labium (adult).

22. Same (naiad).

23. Antenna (adult).

24. Same (naiad).

25. Hind leg (adult).

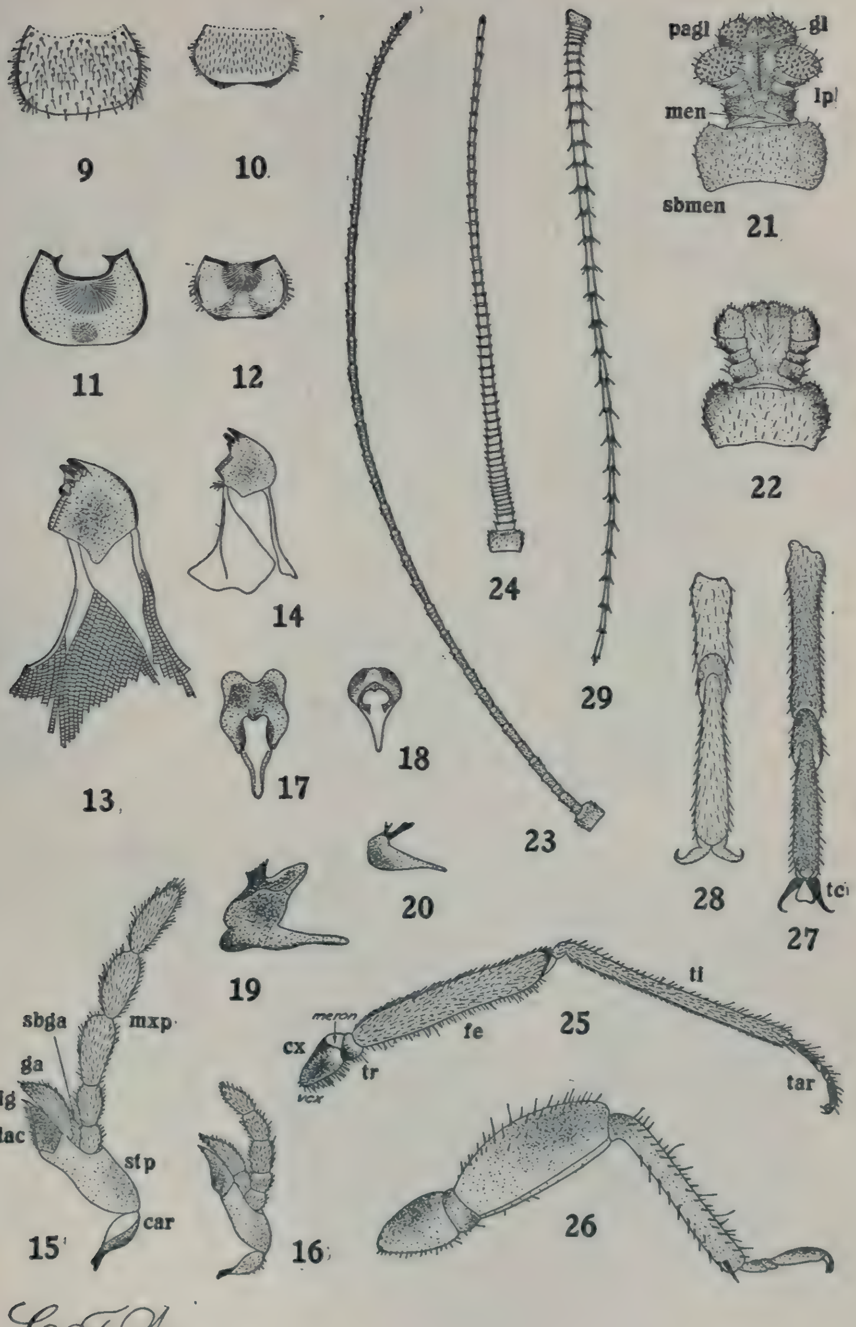
26. Same (naiad).

27. Dorsal view of the tarsus (adult).

28. Same (naiad).

29. Cercus (naiad).

PLATE IV

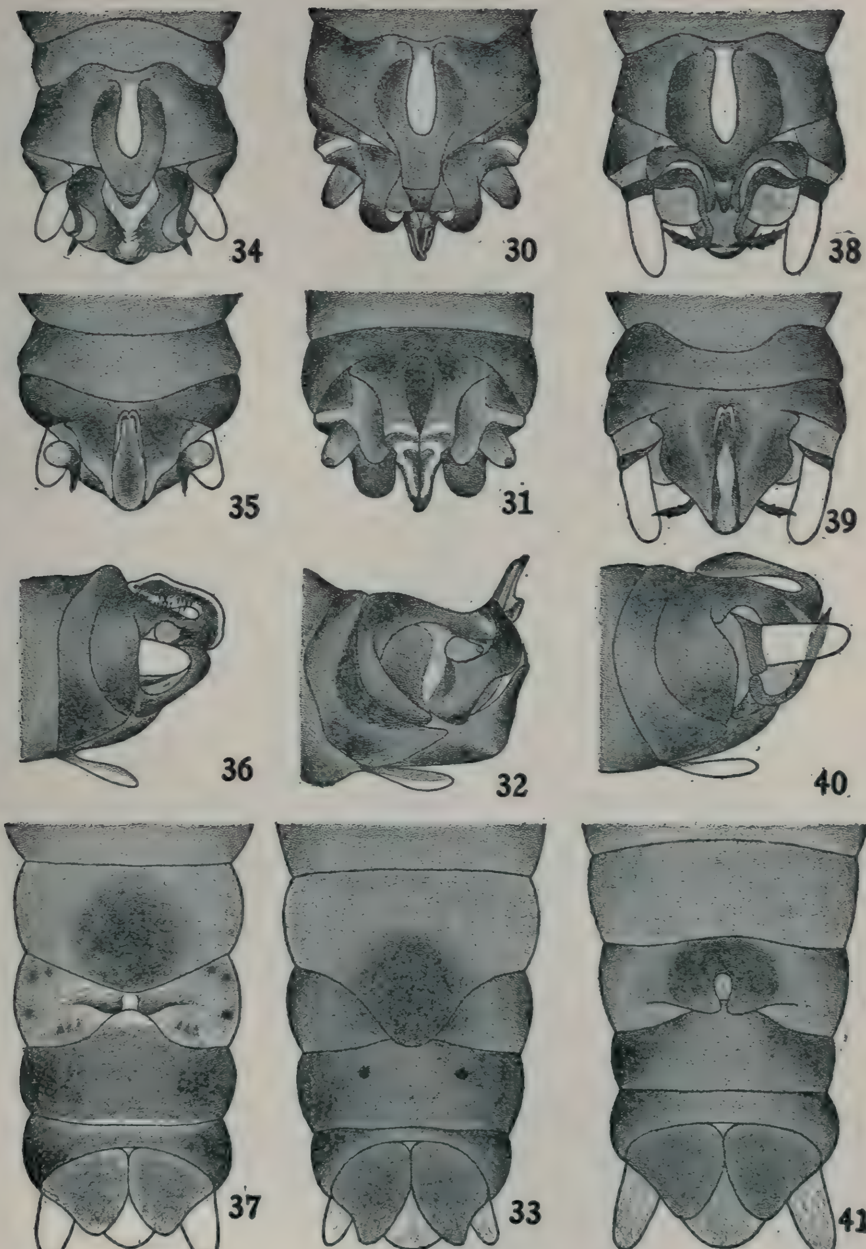

9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
pagl
gl
lp
men
sbmen
sbga
mxp
ga
dig
lac
stp
car
meron
cx
vcx
tr
fe
ti
tar
tc
C.F. Wu.

## PLATE V.

### GENITALIA.

Fig. 30. Nemoura vallicularia; male, ventral.
31. Same; male, dorsal.
32. Same; male, lateral.
33. Same; female, ventral.
34. Nemoura venosa; male, ventral.
35. Same; male, dorsal.
36. Same; male, lateral.
37. Same; female, ventral.
38. Nemoura sinuata; male, ventral.
39. Same; male, dorsal.
40. Same; male, lateral.
41. Same; female, ventral.

PLATE V




C. F. Wu

## PLATE VI.

### MALE GENITAL PARTS.

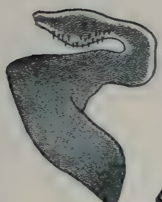
Fig. 42. N. vallicularia; supra-anal lobe, dorsal.
43. " ; same, lateral.
44. " ; subanal lobe with cercus, showing flask-shaped copulatory hook.
45. " ; sub-genital plate, lateral.
46. " ; same, ventral.
47. N. venosa; supra-anal lobe, dorsal.
48. " ; same, lateral.
49. " ; subanal lobe with lobe showing two chitinous bands.
50. " ; sub-genital plate, lateral.
51. " ; same, ventral.
52. N. sinuata; supra-anal lobe, dorsal.
53. " ; same, lateral.
54. " ; subanal lobe with cercus showing two chitinous bands and cercal basipodite.
55. " ; sub-genital plate, lateral.
56. " ; same, ventral.

PLATE VI

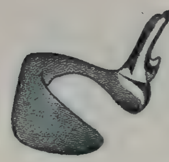
47

42

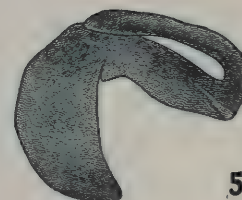
52



48

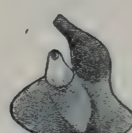


43

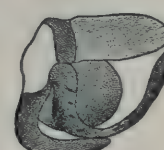


53

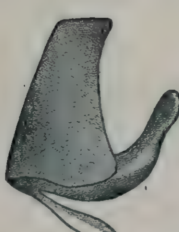
49



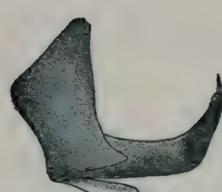
44



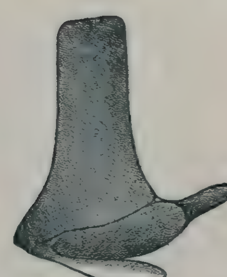
54



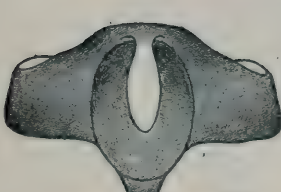
50



45

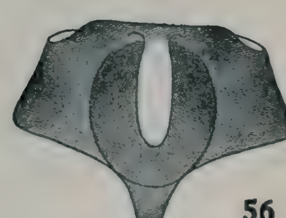


55



51

46



56

C.F.Wu.

# PLATE VII.

## GENITALIA (Continued).

Fig. 57. N. vallicularia, adult; caudal view of male genitalia.

58. N. vallicularia, adult; ventral view of female genitalia, with female sub-genital plate turned up to show the vaginal valves.

59. N. vallicularia, naiad; dorsal view of caudal abdominal segments of male, showing developing supra-anal process in supra-anal lobe, and developing copulatory hooks in sub-anal lobes.

60. N. vallicularia, naiad; ventral view of caudal abdominal segments of male, showing developing median white lobe in ninth sternite.

61. N. vallicularia, naiad; ventral view of caudal abdominal segments of female, showing invagination between the seventh and eighth sternites to form the vagina.

## INTERNAL ANATOMY.

### Skeletal System.

Fig. 62. Tentorium, dorsal view; with the front and part of the epicranium removed to show the anterior, dorsal and posterior arms.

63. Profurca and post-profurca, dorsal view.

64. Same, lateral view.

65. Mesofurca, dorsal view.

66. Same, lateral view.

67. Metafurca, dorsal view.

68. Same, lateral view.

### Secretory System.

Fig. 69. Dorsal view of the secretory system, showing two pairs of salivary glands with ducts opening on the caudo-ventral border of hypopharynx.

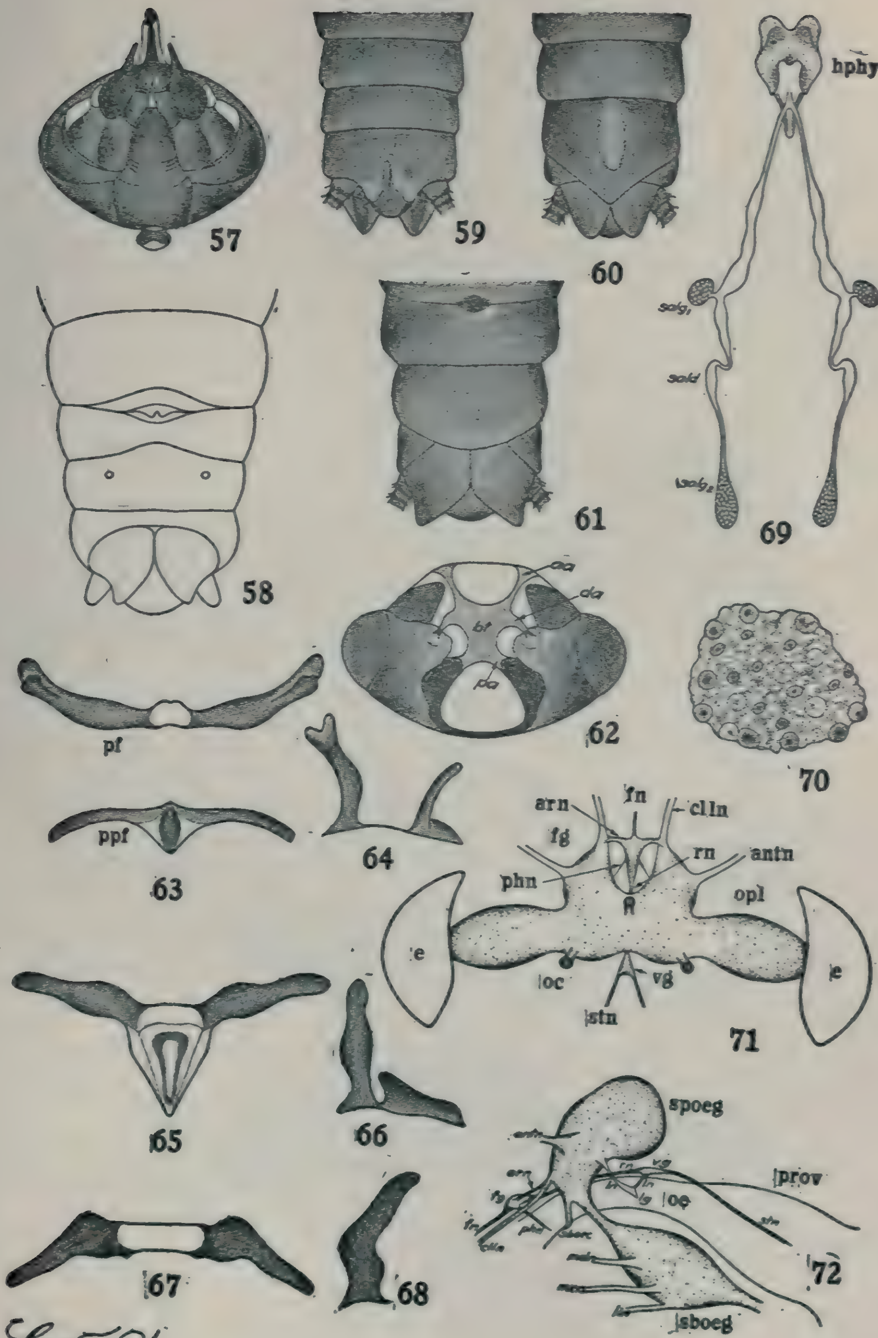
70. Glandular cells with nuclei in the salivary gland.

### Nervous System.

Fig. 71. Supra-oesophageal ganglion with nerves, dorsal view.

72. Supra-oesophageal ganglion with nerves, lateral view, also showing the dorsal and lateral sympathetic systems and sub-oesophageal ganglion with nerves.

PLATE VII


57
59
60
hphy
58
61
69
62
pf
ppf
63
64
70
fn
arn
clln
fg
rn
antn
phn
opl
e
oc
vg
stn
71
65
66
spoeg
prov
oe
72
67
68
sboeg
C.F.Wu.

## PLATE VIII.

### INTERNAL ANATOMY (Continued).

#### Nervous System (Continued).

Fig. 73. Supra-oesophageal ganglion, horizontal section through the center, showing the histological structures.

74. Supra-oesophageal ganglion, vertical longitudinal section through the center of the hemisphere, showing the cauliculus and the relative positions of the three cerebral lobes.

75. Supra-oesophageal ganglion, vertical longitudinal section through the center of the ganglion, showing the central body and the trabacula in cross-sections.

76. Ventral view of the central nervous system, showing the thoracic and abdominal ganglia with their nerves.

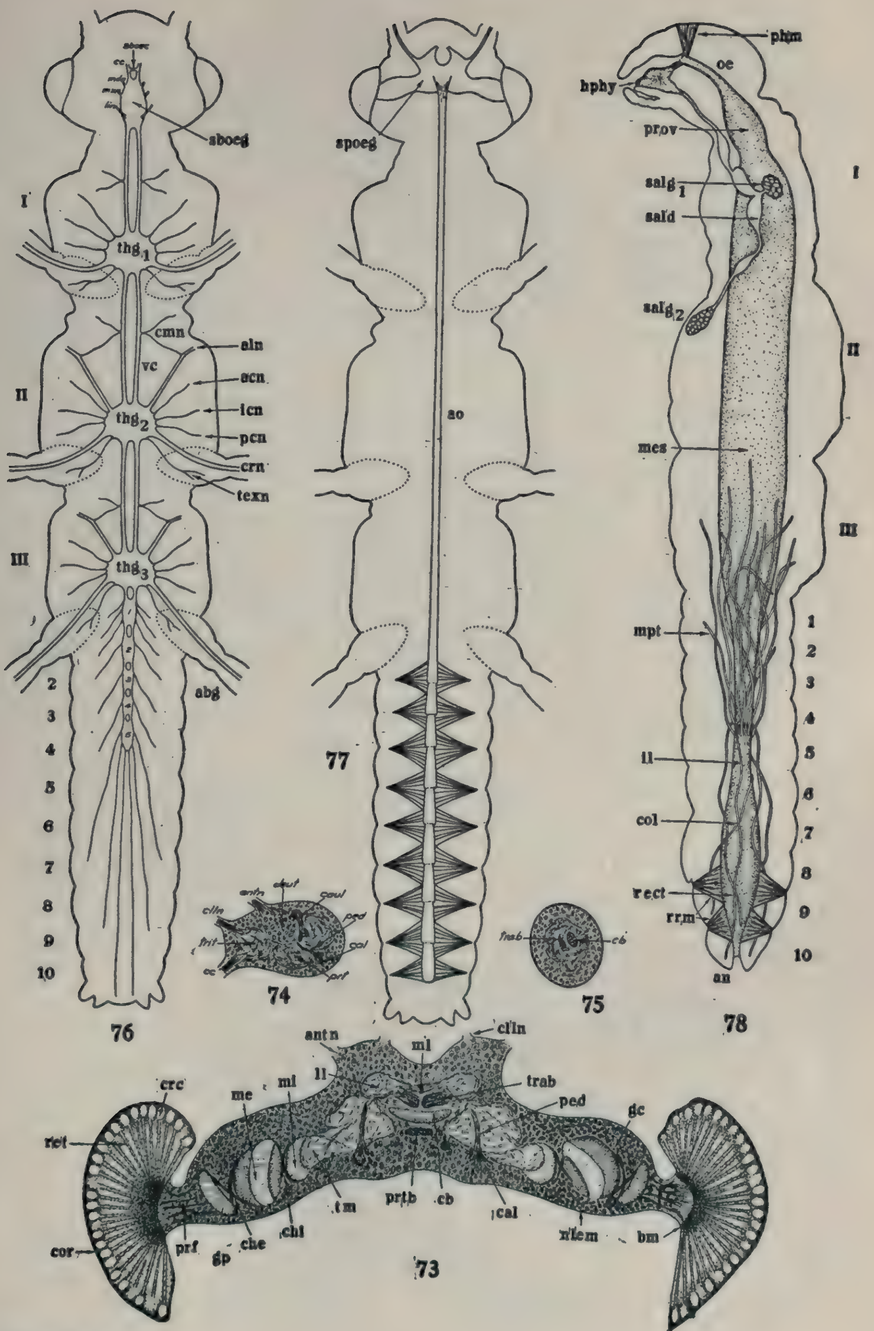
#### Circulatory System.

Fig. 77. Ventral view of the dorsal blood vessel, showing the aorta opening on the ventral side of the supra-oesophageal ganglion, and the nine chambers of the heart with nine pairs of wing muscles of the heart.

#### Digestive System.

Fig. 78. Lateral view of the alimentary canal, showing its principal divisions, the pharyngeal muscle and the radial rectal muscles; also showing the salivary glands with ducts and the Malpighian tubules.

# PLATE VIII




C.F.Wu.

## PLATE IX.

### HISTOLOGY OF THE ALIMENTARY CANAL.

Fig. 79. Oesophagus, transverse section, showing the six longitudinal folds of the epithelium and the heavy circular muscles on the outside.

80. Proventriculus, transverse section, showing the thickened intima and the stomachic teeth.

81. Oesophageal valve, longitudinal section, showing the invagination of the intima into the proventriculus, and the invagination of the proventriculus into the mesenteron.

82. Mesenteron, transverse section, showing the columnar digestive epithelium, the striated border, and the peritrophic membrane.

83. Transition from the mesenteron to the proctodeum, longitudinal section, showing the insertion of the Malpighian tubules.

84. Ileum (small intestine), transverse section, showing the four layers of muscles and the six deep longitudinal folds of epithelium.

85. Colon (large intestine), transverse section, showing the six pairs of longitudinal folds, the large glandular epithelial cells, the thin layer of circular muscles, and the six pairs of longitudinal muscles on the outside.

86. Rectum, transverse section, showing the six rectal folds and the columnar epithelial cells.

87. Posterior portion of rectum, transverse section, showing the reduction of three of the rectal folds to form the anus, the cubical cells, the thick circular muscles, and the circular row of six radial rectal muscles.

88. Proctodeum, longitudinal section, showing the cubical cells of ileum gradually changing into the large glandular cells of colon, and the abrupt change from the glandular structure of colon to the columnar structure of rectum.

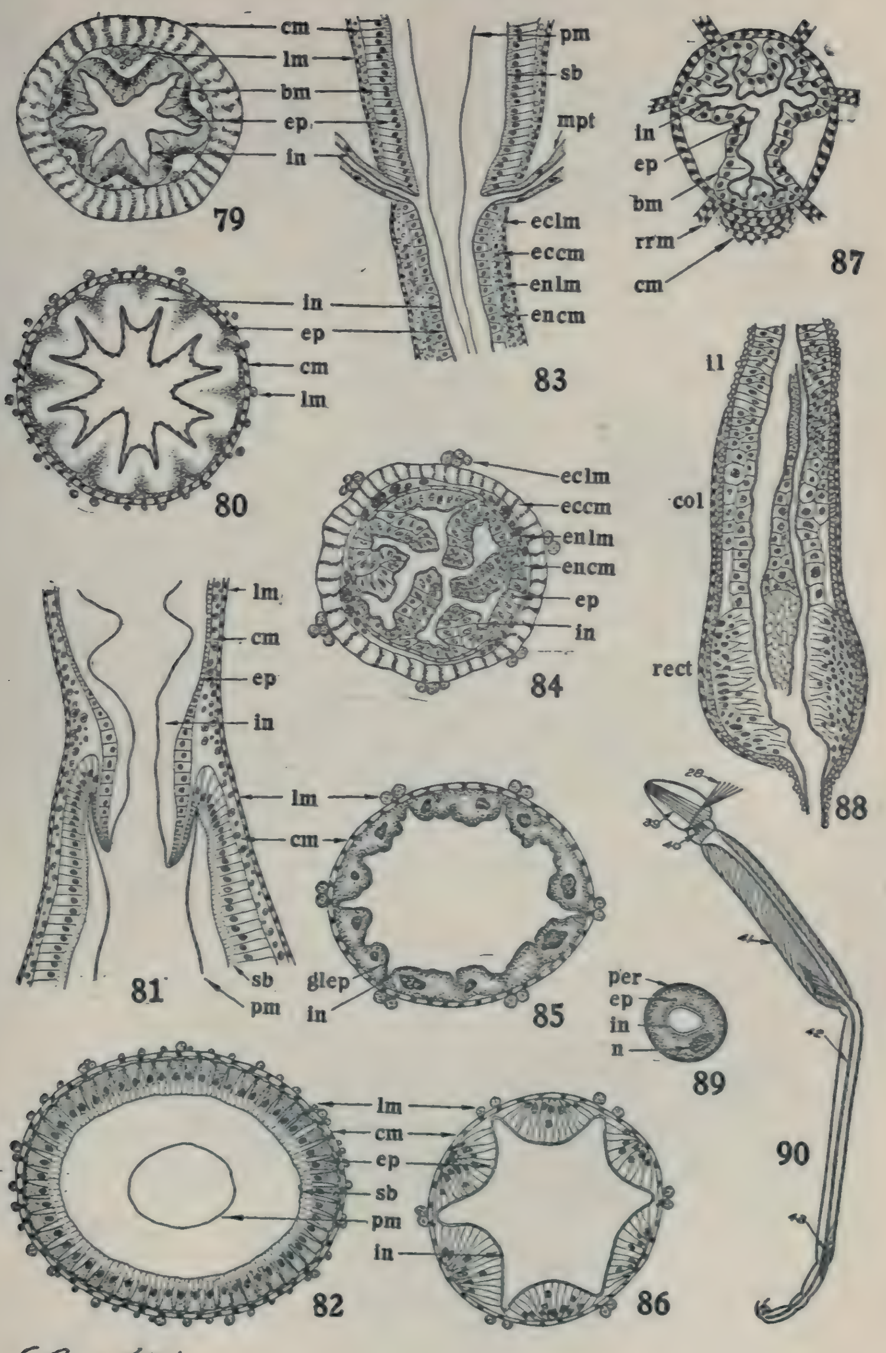
### Excretory System.

Fig. 89. Malpighian tubule, transverse section, showing the peritoneal covering, the large cell with nucleus, and the intima lining.

### Muscular System.

Fig. 90. The Crural Muscles: 39. Coxo-trochanteral.
40. Trochantero-femoral.
41. Femoral.
42. Femoro-tarsal.
43. Tibio-tarsal.

PLATE IX


cm
lm
bm
ep
in
79
pm
sb
mpt
eclm
eccm
enlm
encm
83
in
ep
bm
rrm
cm
87
in
ep
cm
lm
80
il
col
rect
88
eclm
eccm
enlm
encm
ep
in
84
lm
cm
ep
in
lm
cm
sb
pm
81
glep
in
85
per
ep
in
n
89
90
lm
cm
ep
sb
pm
in
82
86
C.F. Wu.

## PLATE X.

### MUSCULAR SYSTEM

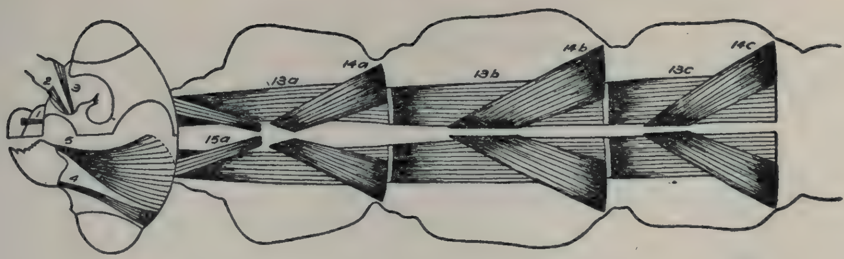
Fig. 91. The dorsal muscles.

92. The dorso-lateral and the lateral muscles; forming the outer layer of muscles lying immediately entad of the body wall on the side.

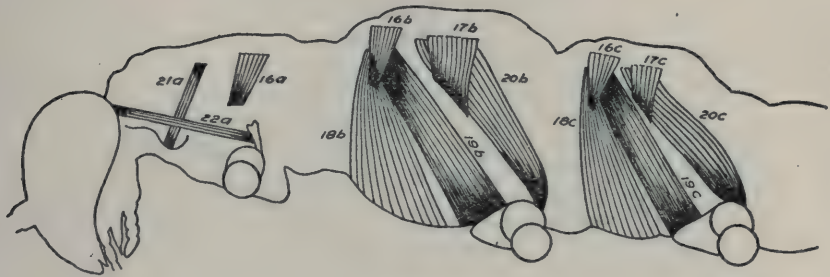
93. The dorso-ventral muscles; the inner layer of muscles lying entad of the dorso-lateral and lateral muscles.

94. The ventral muscles.

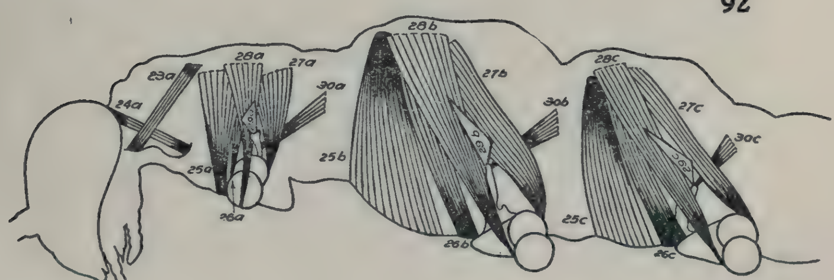
# PLATE X



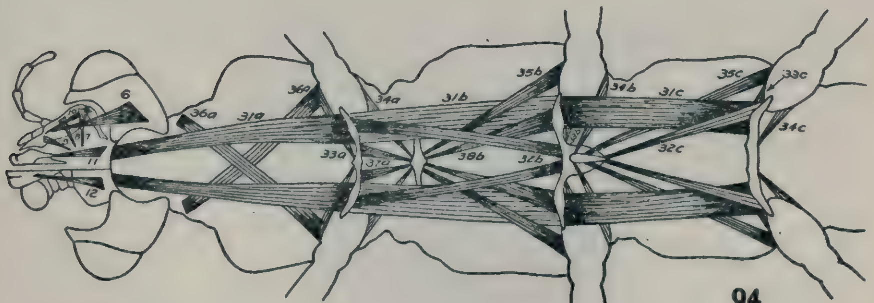

**91**




**92**




**93**




**94**

C.F.Wu.

## PLATE XI.

### MUSCULAR SYSTEM

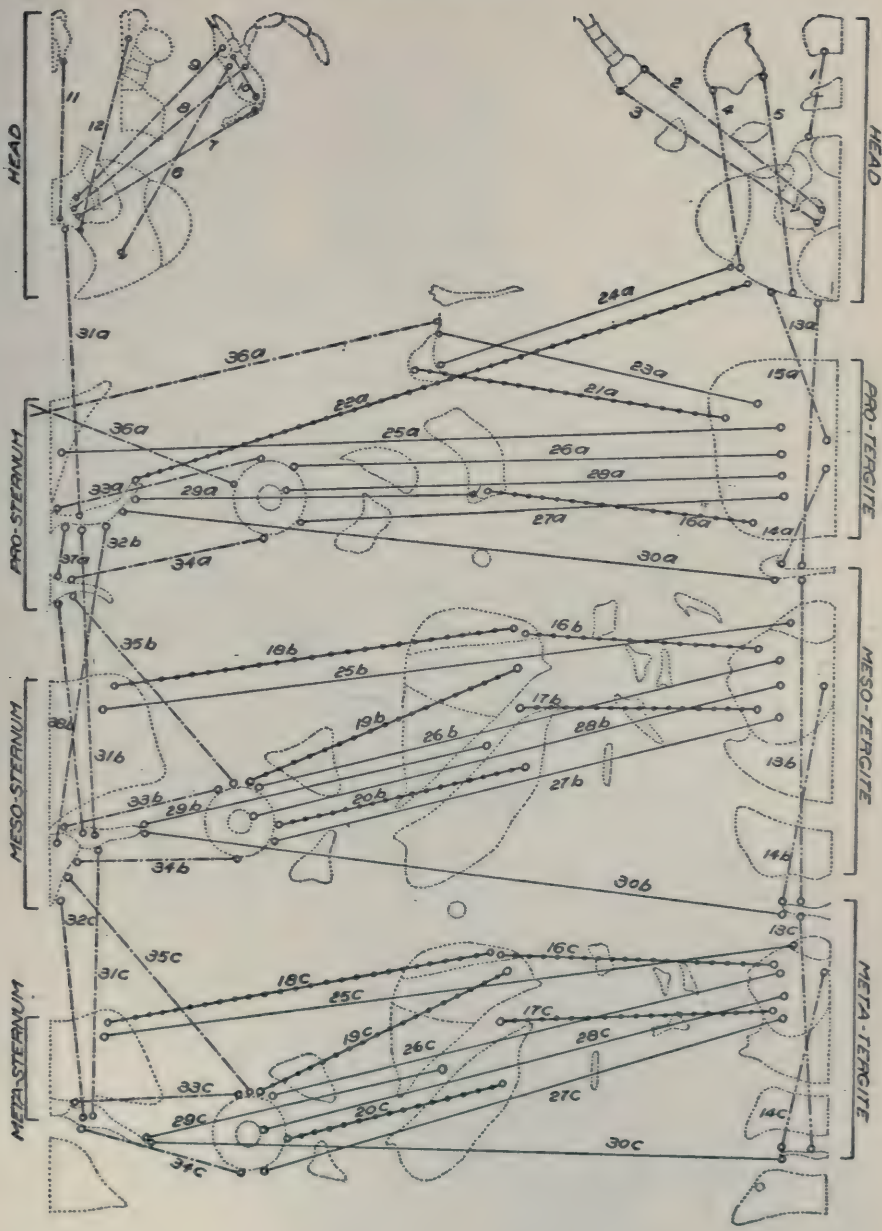
**Fig. 95.** DIAGRAM, showing the attachment of cephalic and thoracic muscles.

(For lettering of sclerites, see Fig. 8 and explanation.)

Abbreviations: (a—prothorax; b—mesothorax; c—metathorax).

| | |
|---|---|
| I. CEPHALIC MUSCLES: | 1. Tentorio-labral. |
| | 2. Anterior Tentorio-antennal. |
| | 3. Posterior Tentorio-antennal. |
| | 4. Outer Mandibular. |
| | 5. Inner Mandibular. |
| | 6. Maxillary-occipital. |
| | 7. Cardo-tentorial. |
| | 8. Tentorio-palpial. |
| | 9. Tentorio-lacinial. |
| | 10. Cardo-lacinial. |
| | 11. Tentorio-hypopharyngeal. |
| | 12. Tentorio-labial. |
| II. THORACIC MUSCLES: | 13. Interphragmal. |
| Dorsal longitudinal | 14. Scuto-phragmal. |
| | 15. Scuto-occipital. |
| | 16. Prescuto-episternal. |
| | 17. Scuto-epimeral. |
| Lateral | 18. Episterno-sternal. |
| | 19. Episterno-coxal. |
| | 20. Epimero-coxal. |
| | 21. Pronoto-jugular. |
| | 22. Furco-occipital. |
| | 23. Inner Pronoto-jugular. |
| | 24. Jugo-occipital. |
| Dorso-ventral | 25. Prescuto-sternal. |
| | 26. Anterior Scuto-coxal. |
| | 27. Posterior Scuto-coxal. |
| | 28. Scuto-trochanteral. |
| | 29. Episterno-furcal. |
| | 30. Intersegmental Furco-phragmal. |
| Ventral | 31. Longitudinal Interfurcal. |
| | 32. Accessory Interfurcal. |
| | 33. Anterior Furco-coxal. |
| | 34. Posterior Furco-coxal. |
| | 35. Intersegmental Furco-coxal. |
| | 36. Jugo-coxal. |
| | 37. Profurco-postprofurcal. |
| | 38. Postprofurco-mesofurcal. |
| III. CRURAL MUSCLES: | 39. Coxo-trochanteral. |
| | 40. Trochantero-femoral. |
| | 41. Femoral. |
| | 42. Femoro-tarsal. |
| | 43. Tibio-tarsal. |

# PLATE XI




— · · — dorsal muscles (fig. 91)    —•—•— dor-lat. & lat. muscles (fig. 92)

— · — ventral muscles (fig. 94)    —— dorso-ventral muscles (fig. 93)

C.F.Wu.

95

## PLATE XII.

### RESPIRATORY SYSTEM.

(Adult.)

Fig. 96. Dorsal view of the adult, showing the dorsal tracheae.

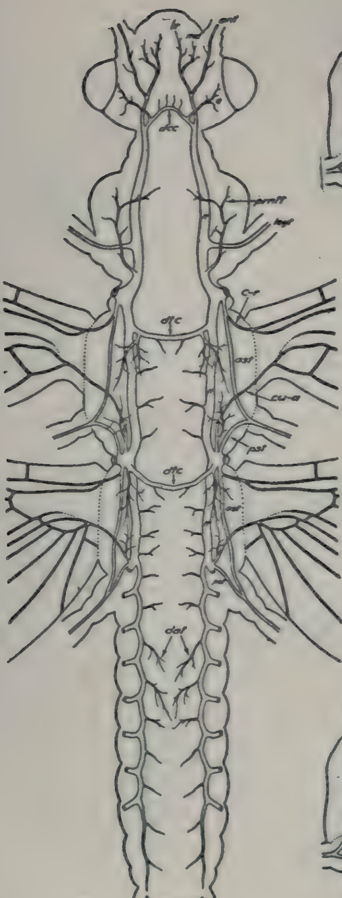
97. Lateral view of the adult, showing all tracheae in the body.

98. Ventral view of the adult, showing the ventral tracheae.

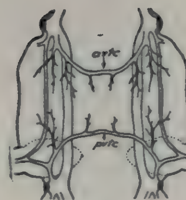
99. Ventral view of the mesothorax, showing a variation in the formation of two ventral thoracic commissures.

100. Ventral view of the mesothorax, showing another variation in the formation of the ventral thoracic connectives.

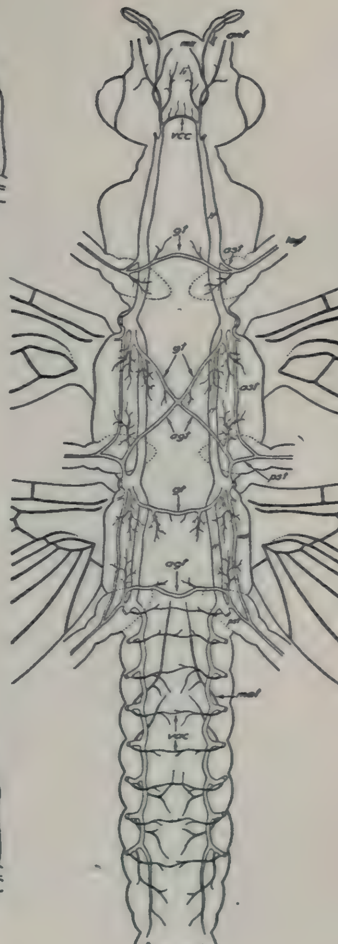
# PLATE XII



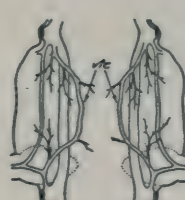
96



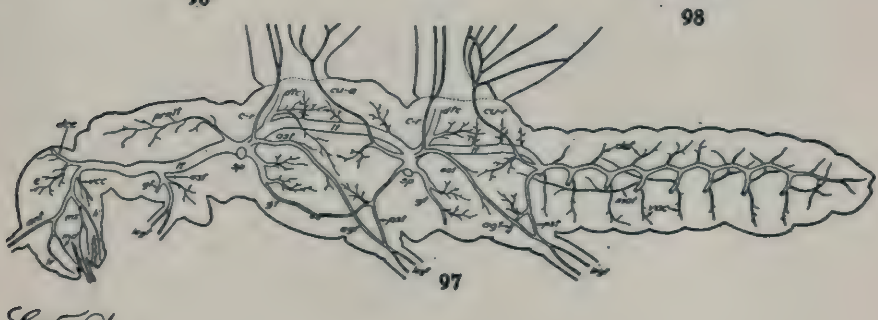
99



98



100



97

## PLATE XIII.

### RESPIRATORY SYSTEM.

(Naiad.)

Fig. 101. N. vallicularia, naiad, ventral view, showing the tufts of peripheral tracheoles.

(For lettering of tracheae, see Fig. 98.)

102. Molted proctodeal intima, showing the rectal blood gills in the proctodeum.

103. Proctodeum, longitudinal section, showing blood gills attached to the large glandular cells of the colon.

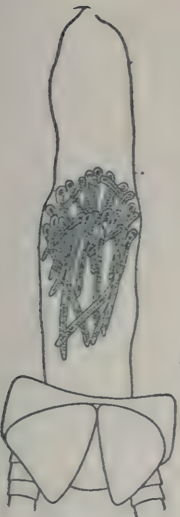
104. N. venosa, naiad, lateral view, showing the tuft of prosternal tracheal gills connected with the longitudinal trunk.

104a. A gill filament, showing the trachea in the center and the tracheoles forming loops at the distal end.

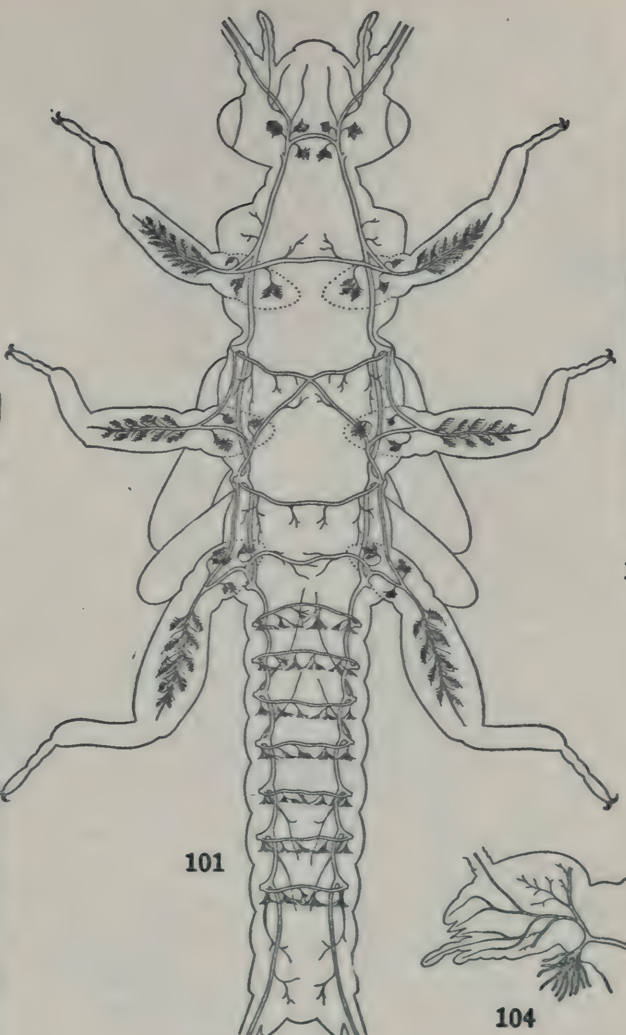
105. N. venosa, prosternal tracheal gill, right side, showing 6 to 7 filaments in each tuft.

106. N. sinuata, prosternal tracheal gill, right side, showing 6 filaments in the outer tuft and 15 in the inner tuft.

PLATE XIII



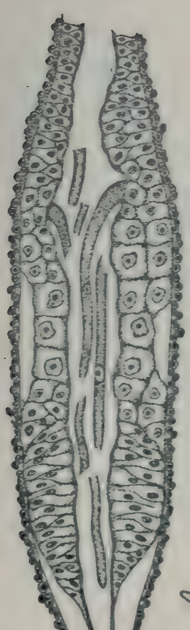
102



101

104a

104



103

105

106

C. F. Wu.

## PLATE XIV.

### REPRODUCTIVE SYSTEM.

Fig. 107. Male, dorsal view, showing the complete male reproductive system with the alimentary canal removed.

108. Same, showing the six pairs of testicular tubes after removing the sac formed by the vasa deferentia.

109. Same, showing the male reproductive organs below the alimentary canal.

110. Male, lateral view, showing the complete male reproductive system in position with the alimentary canal removed.

111. Female, dorsal view, showing the complete female reproductive system with the alimentary canal removed.

112. Same, lateral view, showing the complete female reproductive system with the alimentary canal removed.

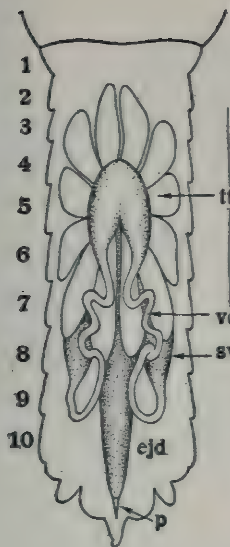
113. Male naiad, dorsal view, showing the developing male reproductive organs.

114. A spermatozoa.

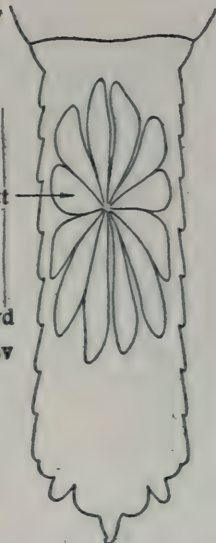
115. Female naiad, dorsal view, showing the developing female organs.

116. An egg, after being deposited and enclosed in a gelatinous coat.

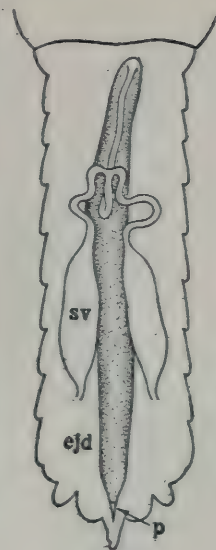
PLATE XIV



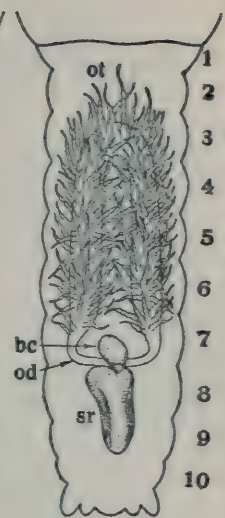

107



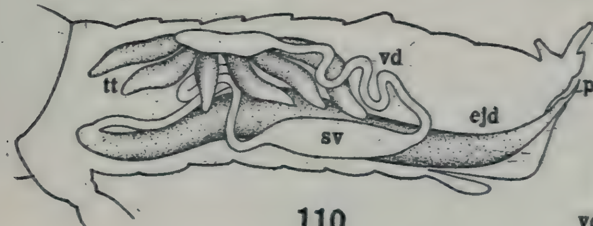
108



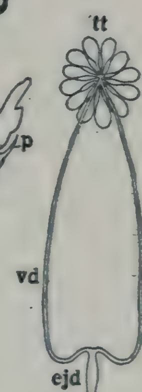

109



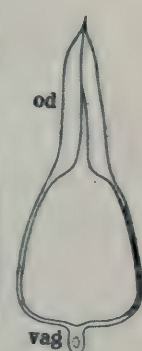

111



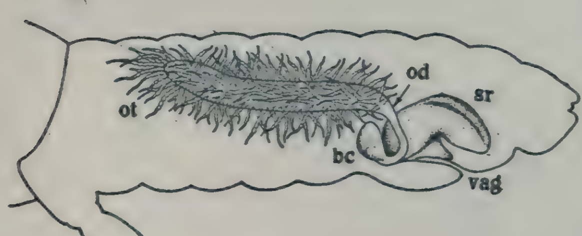

110




113

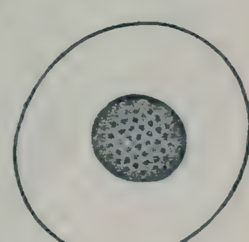



115




112

114



116

C. F. Wu.

## PLATE XV.

### HISTOLOGY OF THE REPRODUCTIVE ORGANS.

Fig. 117. Testicular tube, longitudinal section, showing the spermatozoans arranged in bundles.

118. Vas deferens, transverse section, showing the glandular structure of the epithelium.

119. Ejaculatory duct, transverse section, showing the unusually thick layer of circular muscle on the outside and the intima lining on the inside.

120. Penis, longitudinal section, showing the ejaculatory duct continuing into the male sub-genital plate and terminating in a penis.

121. Ovarian tube, longitudinal section, showing the eggs enclosed by the egg follicles.

122. Oviduct, transverse section, showing the glandular structure of the epithelium.

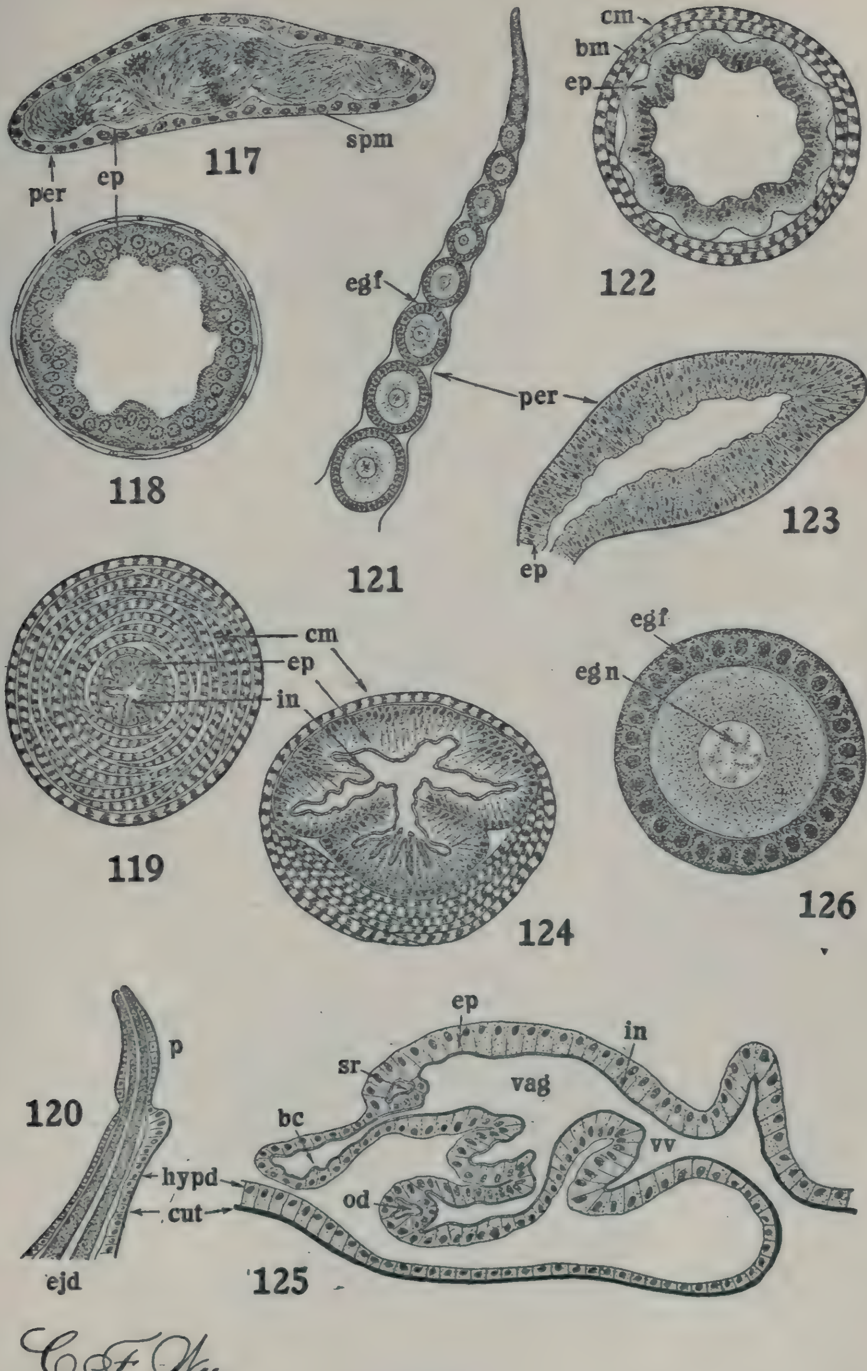
123. Seminal receptacle, longitudinal section, showing the columnar epithelium.

124. Vagina, transverse section, showing the six longitudinal folds of the wall and the intima lining on the inside.

125. Vagina, longitudinal section, showing the vaginal valves and also the seminal receptacle, bursa copulatrix and oviduct opening into the vagina.

126. An egg, a section showing the egg follicle and the egg nucleus.

PLATE XV


117
118
119
120
121
122
123
124
125
126
per
ep
spm
egf
cm
bm
in
egn
p
hypd
cut
ejd
sr
bc
vag
vv
od
C.F.Wu.

## PLATE XVI.

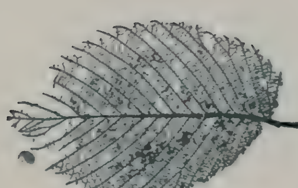
Fig. 127. An elm leaf, skeletonized by the naiads.

128. N. sinuata (adult female) immediately after transformation with the wings held up vertically on the back and the vestigial gills on the prosternum.

129. N. vallicularia, mating, showing in dotted lines the male copulatory hook inserted beneath the female subgenital plate.

PLATE XVI

128



127

129

C.F.Oke.

23

BULLETIN No. 24 1924 ENTOMOLOGICAL SERIES, No. 4

# BULLETIN
of the
# LLOYD LIBRARY
of
# BOTANY, PHARMACY AND MATERIA MEDICA

FOUNDED, ENDOWED AND MAINTAINED BY
CURTIS G. LLOYD
CINCINNATI, OHIO

ENTOMOLOGICAL SERIES, No. 4

# NEOTROPICAL MAYFLIES

By

JAMES G. NEEDHAM and HELEN E. MURPHY

3

# CONTENTS

# NEOTROPICAL MAYFLIES

JAMES G. NEEDHAM and HELEN E. MURPHY

This paper is based on collections made by the Cornell University Entomological Expedition to South America of 1919-20; also on other collections made by Alfred E. Emerson at the Tropical Research Station of the New York Zoological Society at Kartabo in British Guiana; by E. B. Williamson in Guatemala and in Colombia; and by H. S. Parish mostly near Pará in Brazil. It includes a summary of the known ephemerid fauna of the neotropical region, keys to the genera, and descriptions of new species. Its completion was made possible by a grant of money from the Heckscher Foundation for the Advancement of Research, of Cornell University.

All of the material recorded in this paper is preserved in the collections of Cornell University.

Hardly any collecting directed expressly toward obtaining knowledge of the ephemerid fauna has as yet been done in any part of the neotropical region. Not a single mayfly has hitherto been reported from the northeastern section of South America—the Guiana-Venezuela region, and very few, indeed, from the Andean region north of Argentina. From the former, Mr. Emerson obtained a number of species, and in the latter region the members of Dr. Bradley's expedition made extensive collections. Most species are known from the countries that collectors frequent: Argentina, Brazil, Central America and Mexico.

The several collectors on whose materials we report in the following pages, have all collected the immature stages. This has made possible a very large increase in our knowledge of the biology of the group. The only descriptions of South American mayfly nymphs hitherto published, so far as known to us, are a few very inadequate notes by Burmeister (Handb. Ent. II, p. 1015, 1839) and four careful descriptions by Ulmer (Festschr. f. Zschokke, No. 25, pp. 1-22, 1920). Nymphs of most of the known neotropical genera we are now able to describe. Several new and very striking forms of nymphs for which no corresponding adults are as yet known, are among the material before us, and are described and illustrated in the following pages.

Nymphal forms of thirteen genera are here for the first time described. Most noteworthy of these are the following:

| | |
|---|---|
| Metamonius | Baetodes |
| Siphlonella | Thraulodes and |
| Atalophlebia | Hermanella. |
| Atalonella | |

Hardly less noteworthy are the first and the last named of these than is the still unnamed Chilean nymph that was figured by Eaton in his monographic revision on plate 53.

Many parallelisms exist in both adults and nymphs of mayflies; some of those appearing in limpet-shaped forms assumed by the nymphs of lotic species have been pointed out by the senior author in Bull. 68, New York State Museum and in Needham & Lloyd's *Life of Inland Waters,* pp. 369-70. *Hermanella* reveals a new parallelism in the development of protective coverings for the delicate gills. The various devices are as follows: one pair of gill plates becomes operculate and covers the gills behind it in a number of forms; in *Siphlonella* (hereinafter described) it is the first pair that forms the opercula; in *Caenis* it is the second pair; in *Ephemerella* it is the third pair; three parallel developments, even these; but in *Baetisca* and *Prosopistoma,* the thorax extends to rearward covering the gills as with a carapace, which in the former is four-spined and enormously enlarged; and in *Hermanella,* herewith described (Plate 10), the abdomen is shortened and the wing cases are extended to cover and protect the gills.

It will be seen that the endemic genus Campsurus is by far the largest genus, and that most of the species are comprised in this and the four additional Baetine genera, Callibaetis, Baetis, Thraulus and Thraulodes. The two last named and their allies in South America replace the Heptagenine allies of North America; the depressed nymphs of both groups are moulded to similar form in adaptation to life in running streams. The other two genera, Baetis and Callibaetis, include most of the pond species in both continents.

To the student of the neotropical mayfly fauna there are four works of paramount importance; two that deal directly with that fauna, and two that have greatly extended the foundations for the study of the immature stages. These are:

1—Eaton, A. E. Revisional Monograph of Recent Ephemeridae, constituting Vol. 3 of the *Transactions of the Linnaean Society of London, Zool. Series.* This is the ephemeridologist's Bible.

2—Ulmer, Georg. Uebersicht ueber die Gattungen der Ephemeropteren; in *Stettiner Entomol Zeitung,* Vol. 81, pp. 97-144, 1920. This is a valuable reference list, and will greatly aid the student in finding widely scattered descriptions of adult mayflies.

3—Needham, J. G. The Mayflies of New York State; in Bull. 68 *N. Y. State Museum,* pp. 17-62, 1905. Treats immature stages.

4—Lestage, J. Larves des Ephemeres Palearctiques; in Ann. Biol. Lacustre, Vol. 8, pp. 215-457, 1917. Reappears in *Larves et Nymphes aquatiques des Insectes d'Europe,* Vol. I, pp. 162-273, 1921.

THE PRESENT KNOWN NEOTROPICAL MAYFLY FAUNA

| GENUS | | OLD SPP. | NEW SPP. | DISTRIBUTION |
|---|---|---|---|---|
| Campsurus | n | 15 | 12 | General |
| *Tortopus | | | 1 | Peru |
| Asthenopus | | 2 | | Brazil |
| Euthyplocia | n | 1 | | Mexico to Brazil |
| *Campylocia | n | 4 | 1 | Continental |
| Hexagenia | n | 1 | | Mexico to Brazil |
| Metamonius | N | 1 | | Chile |
| Chirotenetes | n | † | | Mexico |
| *Siphlonclla | N | | 1 | Chile |
| Oligoneuria | n | 1 | | Brazil |
| Homeoneuria | | 1 | | Guatemala |
| Spaniophlebia | | 3 | | Brazil |
| ‡Lachlania | n | 3 | | Cuba to Argentina |
| Caenis | n | 1 | | Argentina |
| Tricorythodes | n | 1 | | Guatemala to Argentina |
| Leptohyphes | N | 3 | 2 | Guatemala to Argentina |
| Leptohyphodes | | 2 | | Brazil |
| Melanemerella | | 1 | | Brazil |
| Atalophlebia | N | 1 | 1 | Chile |
| *Atalonella | N | 1 | 1 | Chile and Argentina |
| Deleatidium | N | 2 | | Chile and Argentina |
| Nousia | N | 1 | | Chile |
| Hagenulus | N | 1 | | Cuba |
| *Hermanella | N | | 1 | Iguazu Falls |
| Hagenulopsis | N | 1 | | Brazil |
| Thraulodes | N | 9 | 2 | General |
| Choroterpes | n | 2 | 2 | Mexico to Brazil |
| Thraulus | n | 7 | 2 | General |
| Callibaetis | n | 13 | 2 | General |
| Baetis | n | 9 | 4 | General |
| Pseudocloeon | n | 3 | 2 | Peru and Argentina |
| Cloeon | n | | | |
| *Baetodes | N | | 1 | Brazil |
| Ecdyurus | n | 1 | | Chile |
| Heptagenia | n | 1 | | Mexico |
| 35 Genera | | | | |
| | | 92 + | 35 = 127 Species | |

† Occurrence reported by Eaton, but species undescribed.
‡ Includes Noya of Navas.
N Nymphs described here for the first time.
n Nymphs described previously, mostly from European or North American species.
* The genera marked with an (*) are new.

## Key to the Genera of Neotropical Mayflies

### I. IMAGOS

1—Cubital and first anal veins strongly divergent at base, venation copious (see pl. 1, fig. 5)................................*Ephemerinae* 2

—Cubital and first anal veins parallel at base (in a few forms having reduced and scanty venation appearing a little divergent)..*Baetinae* 7

2—*Ephemerinae:* Posterior fork of the median vein very deep, almost reaching the wing base; two long simple inter-calaries between the first and second anal veins.................................. 3

—Posterior fork of the median vein reaching not more than three-fourths the distance to the wing base.................................. 5

3—Pronotum very short, annular, not widened rearward.....*Asthenopus*

—Pronotum longer, about as long as wide, broader behind.............. 4

4—Middle and hind legs about as long as the fore; vein $M_2$ in hind wing forked for half its length............................*Tortopus*

—Middle and hind legs small rudiments, very much shorter than the fore; no fork in vein $M_2$ of hind wing....................*Campsurus*

5—Posterior fork of the median vein reaches two-thirds to three-fourths the distance to the wing base; vein $Cu_2$ not more strongly bent at its base than is the first anal; subcosta weak and indistinct at its tip.... 6

—Posterior fork of the median vein occupies not more than half the length of the vein; vein $Cu_2$ is more strongly bent at its base than is the first anal; the subcosta is well developed at its tip......*Hexagenia*

6—Behind the first anal vein and parallel therewith, and cutting across the S-shaped veins that join that vein to the margin, one or more strong, straight, intercalary sectors.................*Campylocia*

—Behind the first anal vein no such intercalaries..........*Euthyplocia*

7—*Baetinae:* Posterior fork of the median vein in the fore wing present, normal .............................................. 8

—Posterior fork of the median vein disconnected, vein $M_4$ detached.... 27

8—Intercalaries between first and second anal veins directly connect the former with the wing margin................................. 9

—Intercalaries between the first and second anal veins when present variable but usually more or less independent, and not directly dependent from the first anal in a long series.................... 10

9—Lateral apical angles of ninth abdominal segment produced backward and acutely toothed; second and third anal veins of fore wing parallel at wing margin...........................*Chirotenetes*

—Lateral apical angles of the ninth abdominal segment squarely truncate; second and third anal veins slightly convergent to the wing margin ..........................................*Metamonius*

10—Subcostal vein of fore wing obscure or wanting or visible only at the base; wings greyish; venation reduced to 4 to 7 longitudinal veins in the fore wing and very few rather strong cross veins.......... 11

—Subcostal vein of fore wing visible, well developed and not tucked under the radial vein.......................................... 14

11—Tails 3 ................................................ 12

—Tails 2 ................................................ 13

12—In the fore wing 3 longitudinal veins extend to the wing base between vein R and the first anal; scattered cross veins........*Oligoneuria*

—In the fore wing only 2 longitudinal veins in this space reach the wing base; no cross veins..............................*Homeoneuria*

13—In the fore wing 3 longitudinal veins extend to the wing base between veins R and the first anal; cross veins scattered......*Spaniophlebia*

—In the fore wing 2 longitudinal veins in this space extend to the wing base; cross veins in a single line....................*Lachlania*

14—Fore wings with no free (unattached) intercalary veins; the hind margin ciliate; hind wings wanting in imago (sometimes rudimentary but present in subimago); small species with whitish wings.......... 15

—Fore wings usually with some free intercalary veins; hind margin bare; hind wings generally present in imago (wanting in Hagenulopsis only) ............................................ 18

15—Vein $Cu_2$ and the bisector of the cubital fork extend beside $Cu_1$ to the wing base..........................................*Caenis*

—Vein $Cu_2$ and the bisector of the cubital fork are both much shorter and join $Cu_1$ farther out.......................................... 16

16—Fore wing broadest in the anal region........................... 17

—Fore wing broadest in the cubital region..............*Tricorythodes*

17—Hind leg longer than the front leg......................*Leptohyphes*

—Hind leg equal in length to the front leg............*Leptohyphodes*

18—Anal veins of fore wing 1 and 2 approximated, 2 and 3 separated ....................................*Melanemerella*

—Anal veins of fore wing, 1 and 2 separated, 2 and 3 approximated...... 19

19—Hind wing present............................................ 20

—Hind wing wanting.................................*Hagenulopsis*

20—Claws on each tarsus alike, both hooked......................... 21

—Claws on each tarsus unlike, one hooked, the other blunt............. 22

21—Cross veins at the stigma in the forewing erect; subcosta of the hind wing reaching almost to the wing apex, and the first fork of the median vein normal, attached......................*Atalophlebia*

—Cross veins at the stigma in the fore wing aslant; subcosta of the hind wing ending at the third fourth of the wing length, and the first fork of the median vein disconnected at base..........*Atalonella*

22—Hind wing broadly oval; costal space long and narrow................ 23
—Hind wing angulately broken on the costal border, the costal space wide and generally abbreviated.......................................... 24
23—Hind wing with some cross veins in its posterior half......*Deleatidium*
—Hind wing without cross veins in its posterior half............*Nousia*
24—First and second anal veins of fore wing united in a common stalk ..........................................*Hagenulus*
—First and second anal veins of fore wing separated at base............ 25
25—Posterior median fork present in the hind wing*..........*Thraulodes*
—Posterior median fork absent in the hind wing........................ 26
26—Forceps of male 4-jointed; subcosta in the hind wing extends beyond the costal angulation...............................*Choroterpes*
—Forceps of the male 3-jointed; subcosta in the hind wing ends at the costal angulation ..................................*Thraulus*
27—Hind wing present, often very small.................................. 28
—Hind wing absent......................................................... 29
28—Hind wing with obtuse costal angulation and with cross veins in the costal space; fore wing usually with cross veins in basal half of costal space and ornately colored.......................*Callibaetis*
—Hind wing with no cross veins in costal space and with none in the basal half of this space in the fore wing..................*Baetis*
29—The short marginal intercalaries of the fore wing are in pairs ..............................................*Pseudocloeon*
—The short marginal intercalaries of the fore wing stand singly...*Cloeon*

## II. NYMPHS

1—Mandibles with an external tusk-like ramus projecting forward from the mouth and visible from above..................*Ephemerinae* 2
—Mandibles with no tusk that is visible from above..........*Baetinae* 6
2—Mandibular tusks short, not conspicuous, only their tips visible from above; gills widely outspread.....................*Potamanthus*
—Mandibular tusks long, often longer than the head..................... 3
3—Mandibular tusks flattened, incurved; head with no prominence on the front ................................................. 4
—Mandibular tusks cylindric, upcurved; head with a conspicuous shelf-like frontal prominence.............................*Hexagenia*
4—Mandibular tusks as long as the head...................*Campsurus*
—Mandibular tusks as long as head and thorax together............... 5

* Here also will go the genus Hermanella, known only from the nymph and the venation (see pl. 10, fig. 133).

5—Claw lateral on the lobed tip of the fore tarsus............*Euthyplocia*
—Claw terminal on a truncate fore tarsus..................*Campylocia*
6—Postero-lateral angles of rear abdominal segments tipped with thin flat lateral spines.................................................. 7
—No such spines (except small ones intermixed with hairs in Pseudocloeon, fig. 177); no maxillary gills............................ 11
7—Gills on midventral line of thorax; none on abdomen....*Metamonius*
—Gills absent from midventral line of thorax, present on abdomen...... 8
8—Gills present on abdominal segments 1 to 4, elytroid on 1; mid-dorsal hooks on the same segments........................*Siphlonella*
—Gills on abdominal segments 1 to 7, also on base of Maxillae.......... 9
9—Abdominal gills all dorsal and erect....................*Chirotenetes*
—Abdominal gills appressed, those of the first pair ventral............. 10
10—Tails three* ..........................................*Oligoneuria*
—Tails two† .............................................*Lachlania*
11—Gills present on abdominal segments 1 to 7........................ 12
—Gills absent from one or more of segments 1 to 7, one pair elytroid, covering those behind it........................................ 21
12—Thorax depressed ................................................ 13
—Thorax compressed ................................................ 21
13—Labrum as wide as, or wider than the head; maxillary palpus tipped with an enormous brush of brown bristles, its elongated middle segment visible from above at the side of the head...................... 14
—Labrum narrower than the head; maxillae not visible from above...... 15
14—Labrum wider than the head; labial palpi 2-jointed........*Hagenulus*
—Labrum as wide as the head; labial palpi 3-jointed........*Hermanella*
15—Labrum as wide as the space between the antennae, transverse, narrowly elliptical with an acute median notch in front. Gills long lanceolate, rather thick and densely feather-veined to the tip; femora regularly tapering from near the base, not dilated..............*Atalophlebia*
—Labrum narrower; femora dilated, widest at middle or beyond........ 16
16—Lateral spines on abdominal segments 8 and 9 only.................. 17
—Lateral spines on abdominal segments 2 or 5 to 9.................... 18
17—Lateral spines on segment 9 slender and sharp........(?) *Deleatidium*
—Lateral spines on segment 9 broadly triangular...............*Nousia*
18—Lateral spines on abdominal segments 5 to 9 smoothly pointed; labrum with a wide shallow notch in its front margin; last joint of the maxillary palpus about as long as the one before it......*Atalonella*
—Lateral spines on obdominal segments 2 to 9; labrum not notched on the front border; last joint of maxillary palpus minute............... 19

* Here should also belong the as yet unknown nymph of Homeoneuria.
† Here should also belong the as yet unknown nymph of Spaniophlebia.

19—Gills diminishing in size to rearward.................... *Thraulodes*
—Gills subequal on abdominal segments 1 to 7.................... 20
20—Hind wing present.................................(?) *Thraulus*
—Hind wing absent.............................(?) *Hagenulodes*
21—Gill plates double, at least on the basal segments.................... 22
—Gill plates single on all the segments.............................. 24
22—Hind wings present.................................*Callibaetis*
—Hind wings wanting........................................ 23
23—Labial palpus three-jointed, the middle joint as long as the terminal one ...............................................*Cloeon*
—Labial palpus with its very short middle joint scarcely differentiated from the long terminal one.......................*Pseudocloeon*
24—Gills on segments abdominal 1 to 5, with mid-dorsal hooks on the middle segments .........................................*Baetodes*
—Gills on abdominal segments 1 to 7; no dorsal hooks...........*Baetis*
—Elytroid gill plates of the second abdominal segment widely separated dorsally, and not wholly covering the gills behind them.*Leptohyphes*
—Elytroid gill plates of the second abdominal segment very broad, meeting on the middle line of the back and covering the gills completely.... 19
—Elytroid gill covers narrowed posteriorly................*Tricorythus*
—Elytroid gill covers not narrowed posteriorly................*Caenis*

# CAMPSURUS

This endemic neotropical genus is one of the most remarkable in the world. It abounds throughout the continental tropics; it includes near a fifth of the described species of the entire region; and yet there exist no records whatever concerning the habits of any of the species. The only information of this sort we have been able to obtain is contained in Mr. Emerson's statement that these mayflies gather about the lights in the laboratory at Kartabo in such numbers as to be a nuisance.

It is probably one of the most ephemeral of all Ephemera. It has no legs to stand on, and probably never rests after leaving the water at transformation. Our supposition is that the activities of adult life are confined to the duration of a single flight, during which mating and egg-laying occur. Middle and hind legs are reduced to mere stubs, which show three short segments, coxa, trochanter, and a rudiment of a femur. The fore legs are longer, usually about as long as the thorax is wide. They are weak, and twisted, and more or less suffused with brownish and purplish pigment. The wings are broad and translucent whitish, with a costal strip that is more or less suffused with purplish.

The coloration of the body is rather uniform throughout the genus, and certainty of determinations will rest on the venation of the wings and on the form of the male genitalia. Head and prothorax are always more or less blackish above (the latter often being paler at the sides) and on the sutures of meso- and meta-thorax. The dorsum of the pale abdomen is variously decorated with brownish spots or dashes or black lines across the apical borders of the segments. The tails are always white.

The ovaries of the female occupy the entire abdomen, as shown in pl. 3, fig. 27, and at their rear end they terminate in a pair of narrow chitin-lined convoluted oviducts which extend forward to their separate terminations at the base of the eighth segment. Toward the end of each is an ovoid, thin-walled, uterine dilatation and at the outlet is a pair of sacs that are probably seminal receptacles. Ripe females when suddenly placed in alcohol will often extrude the ovaries *en masse,* as indicated for Campylocia in pl. 3, fig. 21. Eaton has figured this for *Euthyplocia hecuba* (in Biol. Centr. Amer.; Neuropt., pl. 1, fig. 3a). His "peculiar chitinous bristle, seemingly arising from the middle of the apical ventral margin of the seventh segment, associated with the sac," is the released chitinized oviduct.

The eggs of Campsurus, pl. 3, fig. 31, are roundish oval, with a very long filament attached at the micropyle and when coiled, covering this end of the egg as with a cap. It is shown partly uncoiled in the figure. It may be uncoiled to a very great length. Its function is probably to attach the eggs to suitable supports in the water, keeping them from submergence in the bottom mud.

The imagos of this genus retain upon the sides of the abdomen fleshy basal parts of the nymphal gills, with even a few filaments present showing inclosed tracheae.

There are two fairly well-marked sections in the genus:

1. Those species in which vein $Cu_2$ has retained its relations rather closely with $Cu_1$, and in which the prothorax is elevated at its dorsal front border in a median triangular hump that fits against the rear of the head.

2. Those species in which vein $Cu_2$ has become detached wholly from $Cu_1$, and attached more or less closely to the first anal, and in which the prothorax is smoothly truncate across its front border.

In all this order of fragile insects there is hardly anything more fragile or more unsatisfactory as museum material than what this genus furnishes. Not even the venation can be studied aright without often a careful softening, spreading and mounting of the wings, and such is the capacity of these forms for shriveling that even the male genitalia are not always trustworthy. In alcohol or on pins they may twist into positions that cause differences in appearance. We have found the venation of the wings unexpectedly trustworthy in certain features that have hitherto been little used. Having an abundance of specimens of *Campsurus corumbanus* at hand, we mounted thirty-six pairs of wings of this species for detailed comparison, in order to learn what venational characters might be trusted. While there is much variation in individual cross veins, we have found that in the general abundance or scarcity of cross veins and in their distribution among the areas of the wing there is relative stability, and the general relations between the longitudinal veins are quite constant. Venational characters are therefore used as far as available in the following key. The designation of veins is that of fig. 5 on plate 1.

## Nymph

Herr Georg Ulmer has described and figured a nymph of this genus in Zeitschrift für Zschokke. No. 25, pp. 17-19. His was from Tijuca Preto, Rio Negro, Parana. We have a single nymph of a second (undetermined) species of the genus obtained by Dr. J. C. Bradley at Porto America, Brazil, on the 1st of September, 1920. Our specimen is fully illustrated on plate 4. It is a well grown specimen of a very large species measuring about 23 mm. in length of body, with tails 9 mm. additional. The wings are so crumpled within their sheaths as to be of no use in further identification. This nymph differs from Ulmer's in being much larger (his measured 11.5 mm. without tails); in having the teeth on the inner border of the mandibular tusks less regularly serrate, and in having the claw that tips the fore leg less slender and less arcuate.

This specimen is in the Cornell University collection.

## Key to the Species of Campsurus

1—Vein $Cu_2$ of the fore wing at its proximal end occupying a position intermediate between the first anal vein and the bisector of the cubital fork, usually appearing to be conjoined to the latter...... 2

—Vein $Cu_2$ at its proximal end more closely approximated to the first anal, usually appearing to spring therefrom.................... 10

2—Vein $Cu_2$ joining the bisector by a rounded curve.................... 4

—Vein $Cu_2$ ending proximally in a disconnected spur; size small........ 3

3—Cross veins of the hind wing fewer than ten..................*lucidus*

—Cross veins of the hind wing numerous..................*latipennis*

4—Cross veins in costal and subcostal spaces of hind wing numerous (more than ten, and distributed to tip of these spaces; species of largest size .........................................*major*

—Cross veins of costal and subcostal spaces of hind wing fewer (less than six) or wanting (except the humeral); when present restricted to basal half of these areas...................................... 5

5—The two long anal intercalary veins usually attached separately to the first anal vein; two pairs of darker spots on the dorsum of the mesothorax, one pair before and one behind the paler convex middle portion .......................................... 6

—Anal intercalaries conjoined before their attachment to the first anal vein; no tetrad of darker spots upon the mesothorax............ 7

6—Basal curve at origin of vein $Cu_2$ opposite the fork that separates between veins $M_3$ and $M_4$..................................*evanidus*

—Basal curve of $Cu_2$ farther out in the wing—beyond the level of this fork; therefore, first cubital cell longer................*holmbergi*

7—Fore legs yellow..........................................*primus**

—Fore legs purplish........................................ 8

8—Prothoracic dorsum with a large round median dark spot on a paler background behind the transverse suture, this spot connected by a broad trazezoidal band with the black on the rear of the head; spots in the dorsal brown band of the middle abdominal segments —shaped, and placed end to end, a single pair on each segment, their tips pointing backward..........................*violaceus*

—Prothoracic dorsum not as above, pale spots in the brown on the dorsum of the middle abdominal segments roundish.................... 9

---

* This is probably the species whose fore wing was figured by Eaton in Trans. Ent. Soc. Lond. for 1871, pl. 1, fig. 3 as "*Asthenopi* (sp. nondescript); in Mus. M'Lach.; de Texas," and whose hind wing was figured in his Revisional Monograph, pl. 5, fig. 8b, with the statement on p. 41, "In M'Lachlan Museum are several female examples of a Campsurus taken by Belfrage in Bosque Co., Texas, which has the fore legs yellowish, like the hinder legs."

9—One pair of such spots.......................................*scutellaris*
—Two pairs of such spots.......................................*jorgensini*
10—Vein $Cu_2$ joined to vein $A_1$ by a small rounded curve in proximal end of the inclosed space, rather blunt; anal intercalaries arising by a common stalk; pale species....................................... 11
—Vein $Cu_2$ more clossely approximated to vein $A_1$, the inclosed space sharply lanceolate ....................................... 12
11—With few cross veins in the hind wing none (save the humeral) in costal or subcostal spaces.......................................*segnis*
—With abundant cross veins in the hind wing, numerous in basal half of both costal and subcostal spaces.......................................*pallidus*
12—With a pair of pale [-marks placed back to back on the dorsum of each of the middle abdominal segments.......................................*albifilum*
—Not so marked....................................... 13
13—Apical margins of the abdominal segments pale; base of antennae brown .......................................*notatus*
—Apical margins of abdominal segments blackish, forming dorsal half rings; base of antennae purplish....................................... 14
14—A large yellow spot each side of the prothoracic dorsum, well defined and completely encircled with dark purplish....................................... 15
—Yellow of the sides of the prothorax more diffuse, more extended, that of the two sides often confluent in the rear....................................... 17
15—Rear of head behind ocelli pale; pale spots within the brown band on the dorsum of the abdomen sharply defined.......................................*corumbanus*
—Rear of head blackish; spots diffuse obsolete....................................... 16
16—Upper median fork of hind wing deeper than half the length of the wing .......................................*mutilus*
—Upper median fork of hind wing of a depth less than half the length of the wing.......................................*striatus*
17—Upper median fork of hind wing deeper than half the length of the wing .......................................*argentinus*
—Upper median fork of hind wing of a depth less than half the length of the wing; a smaller species with more open venation......*claudus*

### Campsurus Lucidus sp. nov.

Male—Length of body 6 mm.; of wing 7 mm.; of tails more than 21 mm.

A small pale species with a black head, brownish thorax and hyaline wings. The head is black above except a narrow stripe across the rear. Prothorax yellowish with a somewhat darkened median tract and a black dash just before and another just behind the ends of the transverse cervical groove. A high angulate prominence in the front of the prothorax overarches the rear of the

head and is somewhat darker in color. Mesothorax yellowish above. The three usual longitudinal grooves scarcely tinged with blackish, a little more deeply at the rear, and there is a little sooty black pigment about the outer curving grooves before the wing roots. A pale narrow mid-dorsal line begins on the metathorax, on either side of which is a horizontal ⊃ mark, and extends the length of the abdomen, on either side of which are brownish clouds tending to form broad bars across the segments dorsally. Fore legs pale except for a tinge of purplish brown at the tip of the tibia and upon the bodies of all the tarsal segments; claws pale. Wings tinged with violaceous at the base and along the subcostal and radial veins. Stigma unmarked. Venation as shown in pl. 1, figs. 4 and 4a.

This species is allied to the type of the genus, *Campsurus latipennis*, but differs in the form of the genitalia. The basal joint of the male forceps has an elongate triangular projection upon the outer side. The terminal joint is slender, incurved, dilated and hairy at the tip. There is a small rounded notch in the apex of the penultimate ventral segment.

One male; Rio Putumayo between Puerto Alfonso and the mouth of the Rio Igara-Paraná, Aug. 14, 1920, collected by Dr. J. C. Bradley. Holotype C. U. No. 617, mounted on two slides.

### Campsurus Major sp. nov.

Male—Length of body 13 mm.; of wing 20 mm.

This is the largest species of our list, a pale yellowish robust form, destitute of color pattern (in the old alcoholic specimen which is the type), except for a slight darkening of the tibiae of the front legs, the black pigment of the eyes and ocelli, and a purplish-gray tinge to the costal strip of the fore wing, which becomes imperceptible beyond the middle of the wing. There is, therefore, no color to describe, but the species is very distinct from all others by the male genitalia shown in pl. 3, fig. 28. The venation is shown in pl. 1, fig. 5.

The basal segment of the forceps is stout, cylindric, as wide as long and truncate on the apex. The second segment is long, slender, incurved and dilated and spatulate at the tip where it is clothed with hairs. The high frontal prominence upon the prothorax that overlaps the rear of the head is in this species rather sharply triangular.

This species is of larger stature than any of the other species except *Campsurus wappei* Weyenbergh, but it does not at all agree in venation with the figure given for that species. (Tijd. v. Entom., Vol. 26, pl. 10, fig. 1.)

A single male specimen from Buenos Aires sent me by M. Baer, bearing date of December 16, 1898. Holotype, No. 618; genitalia and two wings mounted on slides, remainder in alcohol.

### Campsurus Evanidus sp. nov.

Male—Length of body 8-9 mm.; of wing 8-9½ mm.; of tails more than 26 mm.

Female—Length of body 9½-10½ mm.; of wing 10-12 mm.

General color pale yellowish. Head yellow except immediately about the black eyes and ocelli. Prothorax yellowish, slightly tinged with purplish only at the sides and on the transverse cervical groove. Mesothorax pale brownish with a smudge of purplish crossing front and rear. The two transverse bands thus formed divided by the usual longitudinal sutures into short streaks. Abdomen yellow with a touch of purplish on the extreme base above and a deeper one on segments 6 to 9 becoming darker on the tips of these segments; apical segments of the abdomen, especially 8 and 9 more broadly brownish, the brown divided by a narrow median pale line; segment 10 yellow. Fore legs yellow scarcely tinged with purplish; about as long as the body. Venation, as shown in pl. 1, fig. 1.

The basal segment of the male forceps (pl. 3, fig. 29) is somewhat the shape of a truncated cone, without prolongation of the angles; the second segment is slender, incurved, dilated and hairy at the tip.

Numerous specimens, both males and females, from Pirapora on the Rio Sao Francisco, State of Minas Geraes, Brazil, Nov. 11 to 13, 1919. Holotype, No. 619; wings and genitalia mounted on slides; remainder in alcohol.

### Campsurus Violaceus sp. nov.

Male—Length of body 10 mm.; of wing 10 mm.; of tails more than 32 mm.

Female—Length of body 11½ mm.; of wing 14 mm.

Head blackish above with a tinge of violet about the borders. Prothorax vilaceous brown, very dark in front, becoming somewhat paler toward the rear and with a paler dash each side upon the transverse cervical groove. Sides yellow except for a marginal line and a little angulate spot projecting rearward and laterally from the large purplish tract of the dorsum, which covers more than one-third of the middle of the segment, and a median band that widens forward to the hind angles of the head. Meso- and metathorax of the same violaceous brown color above, deepest on the sutures and on the transverse carinae at the rear. Abdomen purplish brown above, the color deepening toward the rear on all the segments and wholly overspreading segments 8 and 9 with a pale median dorsal longitudinal line on 1-7, and an obscure ⊃ mark invading the brown on each side of these same segments. There is also a faint longitudinal dash sometimes showing in the midst of the brown on segments 8, 9 and 10. Fore legs and bases of antennae are of a clear violet color. The entire costal strip of the fore wings, including the cross veins is strongly tinged with violet. Venation as shown in pl. 1, fig. 8.

The basal segment of the male forceps (pl. 3, fig. 24) is broadly cylindric, with a strong prolongation of the inner angle at the tip and a sparse clothing of short hairs on the surface. The second segment is long and slender, incurved, and spatulate and hairy at the tip.

Two male and numerous female specimens from Santa Fe, Argentina, February 19, 1920. Holotype, male, C. U. No. 620; wings and genitalia mounted on slides, remainder in alcohol.

### Campsurus Scutellaris sp. nov.

Male—Length of body 8½ mm.; of wing 7 mm.

Head black across eyes and ocelli and purplish in the rear. Base of antennae pale scarcely tinged with purple on the under side. Prothorax mostly pale but with a line of purplish about the lateral margins interrupted in the middle of the border at the rear with a brownish triangular patch covering the prominence that overlies the rear of the head, and extending rearward therefrom in a narrow mid-dorsal band. Mesothorax pale above, the median sutures brownish, the other sutures and all carinae more broadly and diffusely bordered with brown. Abdomen obscure brownish with a pale mid-dorsal longitudinal line and pale apical margins to segments 1 to 8, these paler borders outlining brownish quadrangles on each side of the same segments. In the midst of each patch of brown is a very faint ⊃ mark. There is also a double ⊃ mark at the lateral margin of each segment. Segment 9 is all brownish above. Fore legs yellowish with a purplish spot on coxae and trochanter in front. Wings transparent, faintly and rather uniformly milky-white, slightly tinted in the usual costal strip. Venation as shown in pl. 1, fig. 2. There is a border of purplish dots at the very base of the abdomen beneath near the median line, and there is another similar pair underneath the middle of the thorax, and there are some irregular dark dashes upon the sides.

The basal segment of the male forceps (pl. 3, fig. 18) is prolonged at both inner and outer angles, the outer prolongation being three times the size of the inner. The second joint is straight, slightly and regularly widened to the obtuse tip.

A single male specimen from Iguazu Falls, Argentina, January 22, 1919, collected by Dr. J. C. Bradley. Holotype, C. U. No. 621, two wings and genitalia mounted on slides, remainder in alcohol.

### Campsurus Segnis sp. nov.

Male—Length of body 7-7½ mm.; of wing 7 mm.; of tails 21 mm.

Female—Length of body 7½ mm.; of wing 8 mm.

Color pale brownish with blackish head and fore tarsi, purplish brown

abdomen, and hyaline wings. Head mostly covered by the deep black eyes and ocelli. Thorax rather uniformly brownish, slightly darker upon grooves and carinae. Fore legs pale, sooty on the base of the tarsi, and soot lines upon the carinae of the femora. Abdomen brownish with a very faint narrow mid-dorsal line and paler joinings to the segments; lateral margins darker, segment 10 yellowish. The usual darker coloration of the costal strip is restricted to the basal portion of costa, subcosta and radius and is brownish rather than purplish. The female is slightly darker than the male and the color of the abdomen is more opaque with a suggestion of pale spots above on the dorsum of abdominal segments 2 to 8. Venation as shown in pl. 1, fig. 6.

The basal segment of the male forceps (pl. 3, fig. 17) is short, cylindric, with a long external projection, as long as the body of the segment. The second segment is long and slender, dilated, and hairy at the tip.

Three males, Bartica, British Guiana, November 14, 1920, collected by Alfred E. Emerson. A number of both males and females from Igarape-Assu near Para, Brazil, January 25, 1912, collected by H. S. Parish. C. U. holotype, male, No. 622, mounted on a slide.

### Campsurus Pallidus sp. nov.

Male—Length of body 9 mm.; of wing 12 mm.

Pale yellowish species almost destitute of the usual purplish-brown coloration, there being only a faint touch of it upon the top of the head and the dorsum of abdominal segments 5-9, and in its place there is no definite color pattern. The wings are tinged with purplish lightly on the basal half of the usual subcostal strip. The venation is as shown in pl. 1, fig. 3. The fore legs are faint purplish in color, shorter than the body.

The basal segment of the male forceps (pl. 3, fig. 26) is stout, cylindric, oblique, truncate and without prolongation. The second segment is cylindric and straight, or a little dilated at the apex.

One male from above Posadas on the Alta Parana, Argentina-Paraguay, January 18, 1920. C. U. holotype, No. 623; head, legs, wings and genitalia on slide, remainder in alcohol.

### Campsurus Notatus sp. nov.

Male—Length of body 13½ mm.; of wing 11½ mm.; of tails more than 30 mm.

An elegant species with purplish-brown saddle marks arranged serially the entire length of the body. Head blackish above, a narrow line across the occiput and basal segment of the antennae brown. Prothorax yellowish brown with an oval saddle mark of darker color occupying the middle portion of the anterior

half, with a narrow peripheral carina of purplish color interrupted in the middle, as is also a line on the rear of the head. Meso- and metanotum all pale, excepting the sutures and carinae which are brown. The dorsal saddle marks of the abdominal segments increase in size posteriorly until they quite cover segments 8 and 9, each mark being invaded laterally by a round pale spot on either side in segments 2-7; segment 10 paler. Fore legs purplish brown. Costal strip of the fore wings rather uniformly purplish along costal, subcostal and radial veins. Membrane transparent. Venation as shown in pl. 2, fig. 14.

The basal segment of the male forceps (pl. 3, fig. 25) is stout, cylindric and prolonged in an obtuse triangular lobe on the inner side; the second segment is straight, rather short, and slightly dilated at the tip where clothed with a few thin hairs externally.

Four male specimens from Paraguay River, between Puerto Esperança and Corumbá, Brazil, attracted to the lights of a river steamer, December, 1919.

C. U. holotype, male, No. 624, wings, legs and genitalia mounted on slides, remainder in alcohol.

### Campsurus Corumbanus sp. nov.

Female—Length of body in specimens from Corumbá 13½-14 mm., wing 14-14½ mm., and in specimens from Pirapora, length of body 16½-17 mm.; of wing 18½-19 mm.

Head with broad black band between the eyes, extending forward on the middle ocellus; rear of head paler. Base of the antennae purplish brown, a diffuse broad mid-dorsal band of purplish-brown color extends from head to tail; on the prothorax this band is invaded by a pale streak on the cervical grooves and is constricted somewhat at the rear before the purplish peripheral carina; sides yellow. On the mesothorax this band is bounded laterally by the paired dorsal grooves, from whose anterior ends other dark streaks extend outward to the wing roots. Declivous portions of the rear of meso- and metathorax are brownish, remainder pale. Middle abdominal segments with a somewhat paler mid-dorsal band, and the yellow of the sides invades the brown on each segment producing a double row of pale spots, well rounded, and well defined at their inner ends; segments 8 and 9 more extensively brownish, lacking these spots, and showing instead faint longitudinal streaks; extreme apical margins of segments 5 to 8 black above. Fore legs pale violaceous, about as long as the prothorax is wide. Wings with costal strip violet tinted throughout costa, subcosta and radius and intervening cross veins. Venation as shown in pl. 1, fig. 7. Egg and oviducts as shown in pl. 3, figs. 19 and 27 respectively.

A slight variability in the attachment of vein $Cu_2$ to the first anal occurs in this species, the extent of which is indicated in pl. 1, fig. 7B, by two figures of that portion of the wing. This is supplemental to the whole wing therein figured.

Numerous female specimens from Corumbá, Brazil, collected on the 14th to the 23rd of December, 1919, and at Pirapora, Brazil, on the 11th of November, 1919, by J. C. Bradley.

Holotype, C. U. No. 625, mounted on a slide.

### Campsurus Mutilus sp. nov.

Female—Length of body 13 mm.; of wing 15-16 mm.

A large yellow species with deep purplish-black color on top of the head and pale purplish marks on the dorsum of the thorax. The purple of the rear of the head continues in a wide band upon the thorax, becoming much lighter in color and interrupted by a pale streak each side on the cervical groove. The marginal carina of the prothorax is purplish. The still paler purplish color of the front of the mesothorax becomes pale brown on the metathorax. Abdominal segments 4 to 8 with sooty transverse apical bands that extend forward and become more or less connected in a pair of longitudinal streaks, outside which is a row of very obscure paler spots on each side. Segments 8 and 9 paler, segment 10 yellow. Fore legs and base of antennae purple. Costal strip of both wings becomes much paler apically. Venation as shown in pl. 2, fig. 10.

Five female specimens from Amazonas on the Rio Solimões below the mouth of the Rio Iça, Brazil, September 2, 1920, collected by J. C. Bradley.

Holotype, C. U. No. 626, mounted on slides.

### Campsurus Striatus sp. nov.

Female—Length of body 9 mm.; of wing 13 mm.

A rather stout purplish species, with rather open venation, and with deeply colored longitudinal thoracic grooves, and with the dorsal apical margins of abdominal segments heavily marked with blackish. The head black above, including the rear, and the basal segments of the antennae. Prothorax with a large yellow spot each side enclosed by blackish purple. Mesothorax with the three usual longitudinal grooves conspicuously marked with deep purple upon a paler purple field; the lateral grooves that go to the wing roots marked with purple only at their front ends. Metathorax pale. Dorsum of the abdomen heavily marked with blackish at the margins of the segments, this color becoming diffuse anteriorly, especially on the basal segments, thus giving the abdomen a ringed appearance. Fore legs purplish, as are also all the heavier veins of the wing. Wing membranes transparent. Venation as shown in pl. 2, fig. 13.

One female specimen from Rio Paraguay between Puerto Esperanca and Corumbá, Matto Grosso, Brazil, December, 1919.

Holotype, C. U. No. 627, two wings mounted on a slide, the remainder in alcohol.

### Campsurus claudus sp. nov.

Female—Length of body 12 mm.; of wing 16 mm.

A stout black-headed, pale-bodied species with the black of the abdomen concentrated toward the tip. Head all black above including the rear and the basal segments of the antennae. The fore legs also are blackish. Prothorax pale with a diffuse purplish-brown median saddle mark next the rear of the head and a continuous purplish marginal carina. Meso- and metathorax obscure. Abdomen with apical cross bands on the segments very pale, unless on the basal segment, but very well marked upon the middle of the abdomen; blackest on segments 7 to 9. Costal strip of fore wing heavily tinged with purplish-brown color along all the heavier veins and cross veins. Venation as shown in pl. 2, fig. 15.

Vein $Cu_2$ appears to be fused with the first anal for a greater distance outward in this than in any other species.

Two female specimens from Pirapora on the Rio Sao Francisco, Minas Geraes, Brazil, November 11, 1919, collected by J. C. Bradley.

Holotype, C. U. No. 628, two wings mounted on a slide, remainder in alcohol.

## ASTHENOPUS

This genus, founded by Eaton in Trans. Ent. Soc. Lond. for 1771, p. 59, suppressed by Eaton in his Revisional Monograph of Recent Ephemeridae in 1883, and resurrected by Ulmer in Stettiner Ent. Zeit. 81:103, 1920, is distinguished from *Campsurus* by the very short and annular pronotum, and by having rather longer fore feet in the male, these being as long as the body. Ulmer (1. c., p. 107) records three species, all from Neotropial America, none of which was found among the material before us.

## TORTOPUS N. GEN.

Allied to *Campsurus,* which it much resembles in appearance, but differing by important characters in legs and wings. All the legs are degenerate and apparently functionless, but the middle and hind legs are as long as the fore, though slenderer. In the fore wing the vein $Cu_2$ appears to attach laterally to the bisector of the cubital fork, and the latter in turn, by a similar rather long curvature, to vein $Cu_1$. In the hind wing the posterior fork of the median vein is present. The eggs in Tortopus are similar in size and appearance to those of Campsurus, but are much fewer.

Nymph unknown.

Type the following species:

### Tortopus igaranus sp. nov.

Female—Length of body 6-10 mm.; of wing 9½-12½ mm.

Color above yellowish, tinged with plumbeous on top of the thorax; sutures and carinae brown; there is a diffuse portion of purplish brown on the dorsum of the abdomen regularly deepening posteriorly. The head dark purplish above, this color forming a cross band between the eyes including the ocelli; paler in the rear. Prothorax purplish brown with a paler area on each side just within the lateral margin, and in some specimens with a pale transverse line crossing the collar. The paired sutures on the dorsum of the metathorax are sinuous, meeting behind and enclosing a shield-shaped pale field; remainder of thorax pale brownish. Dorsum of the abdomen obscure brownish. In the better colored specimens there is a trace of the pale mid-dorsal line together with two lateral lines. On the basal half the segments are bordered with darker color around their apical margins, and there is a narrow mid-dorsal line on segment 9. Legs (pl. 3, fig. 32) yellowish; those of the first pair about as long as the prothorax is wide, and those of the middle and hind pairs but little shorter. Wings transparent, with *veins purplish throughout*. Venation as shown in pl. 1, fig. 9.

This species is unique in the following points of its venation: the basal fork of the upper division of the median vein in the fore wing is oblique, being skewed forward; the bisector of the cubital fork appears to replace vein $Cu_2$ basally, where it is strongly askew to rear. In the hind wing the rear division of the median vein is forked to a depth equal to one-half the length of that wing. As indicated in the key, middle and hind legs are much better preserved than in any species of Campsurus.

One female specimen from Rio Igara-Paraná, Peru, July 15-17, 1920. One female specimen from Puerto Bermudez, Peru, taken at light on bank above the river, and a dozen other females, among them the type, from Rio Putumayo between Puerto Alfonso and the mouth of the Igara-Paraná, Peru, August 14, 1920.

Holotype, C. U. No. 629, abdomen in alcohol, remainder on slides.

## EUTHYPLOCIA

The single species of this genus as here restricted, *E. hecuba* Hagen from Mexico, is represented in the collections before us by several nymphs from Gualan, Guatemala, collected by Mr. E. B. Williamson. One of these was described by the senior author in Bull. U. S. Bur. Fish., 36:287, pl. 79, figs. 46-51, 1917. It was not there identified beyond the genus; but Ulmer's later description and figures (in *Festschr. für Zschokke* No. 25, pp. 10-12, figs. 5 and 6) enable us to recognize that it belongs at least in this section of the old and wider genus

Euthyplocia. The mouth parts of this same nymph have been figured also by the junior author in Bull. Lloyd Libr. No. 22, p. 16, fig. 21, and pl. 4, fig. 59.

We have also a well-grown nymph and a small young one collected by Dr. J. C. Bradley at Eneñas along the Camino del Pichis, Peru, on July 4, 1920, that seems to differ in having the claw of the front tarsus somewhat shorter, not reaching the level of the tip of the apical process of the tibia.

## CAMPYLOCIA N. GEN.

Similar to Euthyplocia in appearance but differing in both nymphal and adult stages. Behind the first anal vein in the fore wing there are one or two straight intercalary sectors that cut across the short curving veinlets which connect the first anal with the wing margin. In the nymph there is a very different conformation of the antero-lateral angles of the prothorax, and of the tips of the mandibular tusks and of the fore tarsi. Type: *Euthyplocia anceps.*

### Key to the Species of Campylocia

1—A single intercalary behind the first anal vein and parallel therewith, cutting across the curving veinlets that connect that vein with the wing margin .................................................... 2

—Two such intercalaries.......................................*guntheri*†

2—With two short intercalaries in the space between vein $M_2$ and the long intercalary that normally stands before it; two other similar short pairs in the spaces behind veins $M_3$ and $M_4$ respectively......*ampla*

—With no intercalaries in these spaces.................................... 3

3—Second fork in vein $M_1$ of the hind wing at the first third of the length of the wing; a short intercalary between the first and second anal veins; wings broader, oval in form..............................*anceps*

—Second fork in vein $M_1$ of hind wing at midway the length of the wing; no intercalary between first and second anal veins of hind wing; wings narrower, ellipsoidal in form........................*burmeisteri**

### Campylocia Ampla sp. nov.

Female—Length of body 19-24 mm., of wing 22-24 mm.

A large, pale, broad-winged species. Head blackish around eyes and ocelli, paler in the rear and beneath. Prothorax pale, brownish, indistinctly mottled with blackish; its peripheral carina blackish, especially on the obtuse lateral

† Also a nymph from Colombia as noted below.
* According to fig. 7b of pl. 5 of Eaton's Revisional Monograph.

angles before which the color becomes more intense to the cervical groove, where recurved upon the dorsum half way to the median line. Meso- and metathorax pale except the lateral sutures and carinae. Abdomen broadly washed with brownish, this color tending to form broad transverse bands on the middle segments and darkening posteriorly, wholly overspreading segment 9, where it becomes divided by a narrow median pale line. Lateral margins of abdominal segments 2 to 7 somewhat produced and angulate, marked by an oblique brownish streak on exterior half of prominence and bearing on each angle rudiments of basal portion of nymphal gills; on the posterior side of each of these there are a few gill filaments, some of which show inclosed tracheae.

Fore legs wanting; middle and hind legs pale bearing externally lines of brown on the carinae of the femora and tibiae; tarsi paler; a brown spot covers the middle coxa below. Wing dull hyaline, more obscure toward the wing roots, especially in the costal and subcostal spaces. Venation as shown in pl. 2, fig. 12. Genitalia and egg as shown in pl. 3, figs. 21, 22 and 31.

One female from El Encanto, Peru, August 25, 1920, and

One female from Puerto Bermudez on the Rio Pichis, Peru, J. C. Bradley, collector.

One female from Para, Brazil, H. S. Parish, collector.

Holotype from Peru, C. U. No. 630.

### Campylocia Anceps (Eaton Monogr. p. 38).

Some good alcoholic specimens of this species, both males and females, collected by Mr. A. E. Emerson at Kartabo, British Guiana, on October 20, 1920, enable us to present a new figure of the male genitalia (pl. 3, fig. 33) and to add a few new measurements. We have also a few female specimens from Para, Brazil, that were collected by Mr. H. M. Parish, on the 25th of January, 1912. The notes and figure are from the Bartica specimens.

Length of body, male 9.5 mm., female 11 mm.

Length of wing, male 11 mm., female 12.5 mm.

Our specimens agree well in venation with the figure published by Eaton in his Revisional Monograph (pl. 4, fig. 7c), and confirm Ulmer's supposition in Stettiner Ent. Zeit. 81:106 that the male genitalia figured by Eaton under the same number do not belong to this species. Comparison will show that they are much more like Eaton's fig. 7d of the plate cited.

### The Nymph

The nymph of *Campylocia anceps* has been described and figured by Ulmer in Festschr. für Zschokke No. 25, pp. 3-8, 1920. We have a nymph collected by Mr. E. B. Williamson in Colombia that differs very slightly from Ulmer's, but

that seems to combine the added median intercalaries of *ampla* with the added anal intercalary of *guntheri*, and that probably represents a species as yet undescribed. The mounted nymphal wings show both these characters with striking clearness. The wings are wholly suffused (except for the veins) with purple pigment, and would perhaps be colored in the adult.

In this genus the nymphal gills are in part preserved in the adult insects upon the sides of the abdomen, a fleshy basal portion only bearing a few filaments that contain tracheae (pl. 3, fig. 22).

The egg in this genus is broadly elliptical, sub-truncate at both ends and capped over the truncate portion by an extremely long closely coiled filament. One end is shown partly uncoiled in fig. 31 of pl. 3. The extruded egg mass, and the chitinized oviduct are shown in fig. 21 of the same plate.

## HEXAGENIA

This genus, so abundant in all the larger inland streams of North America, appears to be represented southward by a single yellow-winged species in Mexico, and by a fine widely distributed white-backed, brown-lined species in South America. *H. callineuria* of Banks from Colombia, appears on examination of adequate material to be the female of *H. albivitta* of Walker. A fine series of both sexes of this latter species, collected at Kartabo, British Guiana, by Mr. A. E. Emerson in October, 1920, enables us to add descriptive notes and figures (pl. 2, fig. 16, and pl. 3, fig. 23).

### Hexagenia Albivitta (Walker Cat. p. 566)

*H. albivitta* is certainly one of the handsomest of insects. Its delicacy of structure and rich coloration—a chocolate brown body bearing a wide dorsal stripe of chalky white, and glistening wings bordered in front by amber yellow—confer an unusually striking appearance. Walker's specimens are supposed to have come from Brazil. Banks' type was from Colombia. We have besides the Emerson specimens from British Guiana, a single male collected by Dr. J. C. Bradley at Puerto Bermudez, Peru, July 13, 1920.

Male—Length of body 20 mm., wings 14 mm., tails 35 mm.

Female—Length of body ♀ 22 mm., wings 19 mm.

*Male*—On the top of the head there is a zigzag band of brown through the ocelli between the eyes. There is a pair of distinct chocolate brown spots behind this near the occiput, whence start the two long brown lines that extend backward to the tail, bordering on either side the chalky white mid-dorsal stripe. The latter is washed with yellowish on the top of the mesothorax, where some included points in front and a transverse bar in the rear are of a distinct chalky white.

Inclosed within the brown stripe that covers each side of the abdomen there is a row of triangular chalky white spots some of which are confluent dorsally and posteriorly with the dorsal white band. A line of brownish dashes borders the lateral margin of the abdomen beneath, the brown being dilated toward the mid-dorsal line at the front border in each segment.

The front femora are amber yellow, brownish at the tip; tibiae and tarsi, brown. Middle and hind legs pale, extreme tips brownish. Chalky white irregular markings besprinkle the sides of the thorax; wings hyaline, except for the amber yellow costa, with brown veins. Central area of hind wings beautifully marked with small brown blotches bordering the pale veins. Tails honey yellow, marked at irregular intervals with rings of brown.

*Female*—Similar, but lacking the yellow costal strip of fore wing. The extent of the brown upon the abdomen is very variable, the lateral white spots being sometimes wholly enclosed with brown, sometimes wholly confluent with the dorsal white band.

Venation and genitalia of the male are as shown in pl. 2, fig. 16, and pl. 3, fig. 23, respectively.

## METAMONIUS?

To this genus there is doubtfully referred a very curious type of nymph from Chile, having obvious relationship with Chirotenetes and yet differing very markedly from all known Ephemerid nymphs in lacking dorsal gills upon the abdomen, and in having unpaired mid-ventral gills beneath the thorax. Chirotenetes is known in the neotropical region only from undescribed specimens reported by Eaton (Biol. Centr. Amer. Neur., p. 16) from Mexico. Metamonius is a monotypic genus from Chile.

The two specimens at hand are grown nymphs about ready for transformation, the wings being already crumpled within their sheaths. By carefully removing the fore wings from their sheaths, softening them in glycerine and spreading them out upon a slide, portion of the venation could be made out. So much as appeared is shown in pl. 5, fig. 51. No corresponding adult mayflies were obtained. When this venation is compared with Eaton's careful figure of *Metamonius anceps* (Rev. Monogr., pl. 20, fig. 34b), allowance being made for the elongation of the wing at transformation, it will be seen that the agreement is fairly close. There is the same general disposition of forks and veins, the same one-sidedness in the branching of the cubital vein, with skewness to the rear, and the same incurvature of the second and third anal veins to the hind margin, but the veinlets connecting the first anal vein with the hind margin are forked and appear to traverse a wider area than in Metamonius.

The nymph agrees roughly with the nymph of Chirotenetes in having gills upon the base of the maxilla (though there are but two single filaments instead of

a bundle of filaments), and in the general conformation of the mouth parts (though its labial palps are very much more enlarged). It is unique in having a single pair of gill filaments upon the labium. In its cowl-shaped head and its short spiny legs it differs conspicuously from Chirotenetes. Whether so different a nymph can belong to a genus so closely allied to Chirotenetes as is Metamonius seems doubtful; yet it is either of that genus or of one as yet undescribed.

The characters of this nymph are so fully set forth in plate 5 as to call for no description, beyond the few notes and data hereto appended.

### METAMONIUS? SP? (nymph)

Length of body 12 mm., tails 7.5 mm., additional.

Color wholly blackish (though in younger nymphs possibly not so; these were ready for transformation) only a little paler beneath; the long hairs fringing the femora beneath are tawny yellowish brown; the gills are dirty whitish. These are as shown in the figures; two pairs on base of maxillae, one pair on base of labium; one pair at base of fore legs within, and single mid-ventral gills on each of the three thoracic segments. There are no signs of gills upon the abdomen.

Head broadly rounded to a dome-shaped frontal prominence, its sides overhanging the mouth parts (as indicated by the dotted line in fig. 52 of pl. 5). The clypeus is seen from above, but not the labrum, which is underneath; the latter is densely hairy, especially from a line across its base; the hairs stiff and bristly, some as long as the labium itself; the front border is distinctly concave. Antennae short, hardly surpassing the tip of the labrum.

The angulate lateral margins of the abdominal segments are beset with spinules. The apical ventral margin of the ninth segment is produced to the level of the tip of the tenth segment and widely notched, with a short acute tooth at either side of the notch. Tails 2.

Two male nymphs from Puerto Varas, Chile, April eighth or ninth, by Dr. J. C. Bradley.

## OLIGONEURIA

A single female imago of the sole known neotropical species *Oligoneuria anomala,* being well preserved in alcohol, shows certain characteristics of this species that have not yet been well described, and therefore a few descriptive notes are here added.

### OLIGONEURIA ANOMALA

Female—Length of body 10½ mm., length of wing 9 mm.

Head brown above, with a narrow pale line each side bordering the eyes, the two lines connected across rear of head to form a faint U mark. Prothorax brown,

with five longitudinal pale lines, the narrow median one and two similar sub-marginal ones on the border, less distinct; a pale tract on either side lying in an intermediate position. Mesothorax paler, touched with brownish at front and rear. Metathorax also darker at rear. Abdomen brownish above, with paler joinings to the segments, a pair of pale dots within the brown of the dorsum that are at once sub-basal and sub-median on segments 2 to 9. There are two very narrow darkish parallel brown lines running lengthwise of the abdomen between the pale dots; these lines become sub-joined on the apex of segment 7, into one that is mid-dorsal on segments 8 and 9. Tails short, blackish with paler tips, as long as segments 7 to 10 taken together, medians and laterals about of equal length. Under parts of entire body pale. The rudimentary legs are clouded with brown on all segments; fore legs paler than the others, as well as weaker. Frontal carina of head produced downward in a triquetral snout, which is thick and bare and papilliform, lobed at the tip, as long as the head, and of a very black color. Egg, as shown in pl. 6, fig. 76.

## SIPHLONELLA N. GEN.

This name is proposed for a remarkable Baetine nymph from Chile, that is certainly very different from anything hitherto made known. It has double lamelliform gills on abdominal segments 1 to 4 only, on segment 1 elytroid and covering the others; it has large mid-dorsal hooks on these same segments and on these four only. It combines these characters with a Siphlonurus-like series of lateral spines on the sides of the abdomen, and form of body, and appearance, together with Cloeon-like claws.

The venation of the nymphal wings shows affinities with Siphlonurus rather than with Cloeon; for the posterior median fork of the fore wing is complete ($M_4$ not detached), and the hind wing is broad and copiously veined. Unfortunately the specimens are not well enough preserved to show the venation in full detail; but we have been able to make out that in the fore wing the numerous costal cross veins at the stigmal region are very oblique and variously anastomosing, and the posterior median fork is somewhat unilateral being slightly askew to the rear, as in common in Siphlonurine genera. The hind wing in the nymph is about as broad as it is long, with a rather wide and straightish costal border (in which no cross veins can be clearly seen) for two-thirds the wing length, then an oblique declivity of the margin (apparently with thickened border), then a further straight extension in an obtusely triangular, terminally rounded wing apex. In this apical portion at least are numerous cross veins; the basal parts are not clear, and no forks can be distinctly seen; 12 or 13 longitudinal veins behind

subcosta can be seen reaching the wing margin. These characters should be sufficient for recognition of the adult when found.

The nymph may be described as follows:

### Siphlonella Ventilans sp. n.

Length of body 10 mm., of tails 4 mm., additional.

Color translucent greenish brown, with ringed legs and tails. Head and thorax without distinct color pattern but with extensive mottling of lighter and darker throughout. The better colored specimens show on the dorsal surface of each of the middle abdominal segments a large brownish basal spot shaped like the keystone to an arch, with another similar one set upon it, outspread against the hind margin. Rearward these spots are divided by paler; mid-laterally on these segments the brown tends to form three small pale clouds.

The tails are three, bare at their slender and flexous tips, the middle one slightly shorter. They are obscurely ringed with brown at the apex of alternate segments; the lateral ones are heavily fringed within and thinly fringed without, where beset with close laid single spinules, one on each segment, and each as long as its segment. The hairs of the inner web are all uniformly dull gray.

Legs pale, with a faint dark cloud at two-thirds the length of the femora above, a conspicuous spot on the very oblique suture between tibia and tarsus and another on the top of the tarsus. Tibia and tarsus are consolidated to simulate a single segment, of which the former composes only a third part (pl. 9, fig. 104). Claw Cloeon-like, as long as the tibia (half as long as the tarsus) smoothly and very gently curved to a slender tip.

The abdomen is depressed with thin sharp lateral margins that terminate on each of segments 1 to 9 in backwardly directed, thin, sharp lateral spine, triangular on segment 1 and becoming longer and sharper to rear, on 9 about as long as is segment 10. There are mid-dorsal spines on segments 1 to 4, on 1 erect, on 2 to 4 directed to rearward like the teeth of a circular saw, thin, flat, acutely tipped. The gills are restricted to segments 1 to 4. On 1 they are elytroid, broader than the wing sheaths, which they resemble, being traversed lengthwise by palmately arranged and branching pigmented tracheae, and being somewhat similar in shape, though less pointed at tips. They are crossed by a pale suture-like line in the middle. All are double, and except on segment 1, where the anterior lamella is indurated, the upper or anterior lamella is reduced in size and lies closely upon the base of the posterior; the pairs grow smaller to rearward, and only the top plate of the first pair is pigmented; this one overtops and conceals all the others. See pl. 9, figs. 103, 104, 109, 110, 116 and 117.

Half a dozen nymphs, mostly well grown from Butalcura, Chile, April 5, 1920, collected by Dr. J. C. Bradley.

Holotype, C. U. No. 631, mounted on slides.

## LACHLANIA

Several nymphs of this genus were collected by Mr. E. B. Williamson in Guatemala. Some of the mouth parts of this nymph were figured by the junior author in the Bulletin of the Lloyd Library No. 22 in pl. 4, fig. 56, and in pl. 5, fig. 83. These may belong to the species *L. lucida,* the only one yet known from Guatemala. The type of the genus *L. abnormis* Hagen is from Cuba. Ulmer (Festschr. für Zschockke No. 25, p. 20) has described the nymph of *L. pallipes* (under the name Noya pallipes, following Navas) from Argentina, and it is so nearly identical with the specimens before us as to be surely congeneric with them. We are not, therefore, retaining the genus Noya. The venation of the nymphal wing of one of our specimens (see pl. 6, fig. 68) shows them to belong to *Lachlania.* The only deviation shown by our specimens from Ulmer's figures, are in the shape of the claw of the front tarsus, which in ours is stouter and more sharply hooked. Our largest specimen measures about 25 mm. in length of body with tails 12 mm. additional; abdomen 9 mm. Details of structure are illustrated in the figures on plate 6.

## LEPTOHYPHES

This genus of diminutive, well nigh dipterous mayflies ranges over the continent and is represented by four described species, to which two new ones are now added, and the nymphs of the genus (two undetermined species) are for the first time here described. These may be separated by the following keys:

### Adults

1—Large species (wing 8 mm.), black in color.................. *eximius*
—Smaller species (wing 3 to 6 mm.), yellowish or brown.............. 2
2—Brownish species from Central America.......................... 3
—Yellowish species from below the equator........................ 4
3—Dark or dull brown.......................................*costaricanus*
—Chestnut brown ............................................*brevissimus*
4—Hind wings veinless; their costal process slightly recurved......*mollipes*
—Hind wings with two long veins; their costal process longer and very strongly recurved; its point blunt............................ 5
5—Penes of the ♂ divaricate and blunt at tips.................*peterseni*
—Penes of the ♂ parallel and acuminate at tips................*indicator*

### Leptohyphes Mollipes sp. n.

Male—Length of body 3 to 4.5 mm., wing 3.5 to 4.7 mm., tails 4 mm.
Female—Length of body 4.5 mm., wing 4 mm.

Color pale brown similar in males and females, with blackish head and whitish abdomen and tails. Disc of the prothorax very wide, more or less shield-shaped, wider than the head, flat above with a pale median area and a 4-rayed pale spot each side surrounded by blackish brown. Mesothorax pale brown with only narrow blackish isolated lines on some of the more prominent carinae and two pairs of blackish marks beside the dorsal crest. Abdomen whitish, the two basal and the three apical segments washed with brown above. A wash of the same color darkens the extreme tip of the tails. There is a faintly indicated longitudinal stripe along each side of the abdomen. All femora and tibiae are faintly tinged with purplish brown and all tarsi are white. Venation as shown in pl. 7, fig. 89. There are no veins at all in the hind wing. The genitalia of the male are shown in pl. 7, fig. 90.

Both imagos and subimagos of each sex from Cordisboro, Brazil, in November, 1919; collected in trap-lantern.

Holotype, C. U. No. 632, wings mounted on a slide, remainder in alcohol.

### Leptohyphes Indicator sp. n.

Male—Length of body 3½ mm., of wing 4½ mm., of tails 5 mm.

Similar in form and color to the preceding but with the prothorax less broad and more blackish. The abdomen is faintly ringed with fuscous on each segment above; the hind femur has a broken ring of the same color near the apex. Venation as shown in pl. 7, fig. 77. In the hind wing there are two faint longitudinal veins as in *L. peterseni,* the rear one shorter and fainter, the costal process is very long and slender and gently arcuate to a long, sharp, recurrent point. Genitalia of the male as shown in pl. 7, fig. 78.

One male, Iguazu Falls, Missiones, Argentina; collected by Dr. J. C. Bradley.

Holotype, C. U. No. 633-1, wings and genitalia on a slide, remainder in alcohol.

### Key to the Nymphs of Leptohyphes

1—Prothorax normally angulate at its anterolateral angles.

*Leptohyphes No. 1*
(From Guatemala)

—Prothorax with a roll rim at the front immediately behind which is a flat ledge on the lateral margin and between the two a notch as viewed from above.

*Leptohyphes No. 2*
(From Peru)

### Leptohyphes Nymph No. 1

This minute nymph having a length of body of 5 millimeters may belong to *L. brevissmus* Etn, the only member of the genus hitherto known from Guatemala,

whence it comes, but the venation shown by the nymphal wing (see pl. 7, fig. 84) is more like that of the type species *L. eximius* as figured by Eaton in his Revisional Monograph (pl. 15, fig. 25). It has square cut angles to the front of the prothorax, a fringe of flat, short, oval and numerous (20 to 24) scales fringing the outer margin of the middle femora, lateral spines on the terminal abdominal segments that are closely applied to the sides of the body, and the mid-dorsal apical margin of segment 10 is produced into a triangular lobe.

The lacinia of the mandible of this species is figured by the junior author in the Bulletin of the Lloyd Library, No. 22, pl. 4, fig. 52. Herewith we present a small figure of the nymph and another of the venation of the fore wing of the same (pl. 7, figs. 88 and 84).

An immature nymph in alcohol, collected by Mr. E. B. Williamson at Gualan, Guatemala, in July, 1905, and now in the Cornell University collection.

### Leptohyphes Nymph No. 2

This nymph from Camino de Pichis, Peru, we present in plate 7 in more detail. It is a dirty brownish specimen, showing no venation in its wings. It is blackish on the front of the head, on the top of the mesothorax and the dorsum of that part of the abdomen posterior to the gills; it is paler beneath and on antennae, tails and tarsi. As indicated in the key there is a notch just behind the front angle of the prothorax between the frontal rim and the prominent flat lateral carina. Gills are as in the other species, on segments 2 to 6 of abdomen, the first semi-operculate, oblique, indurated; the others smaller, thinner, more delicate.

The single nymph known was collected by Dr. J. C. Bradley on July 4, 1920, at Eneñas on the Camino del Pichis, in the Cerro de Sal, Junin, Peru, at an altitude of 1,491 meters.

## ATALOPHLEBIA

This antipodean genus is represented in Chile by two species: *A. chilensis* (Eaton, Rev. Monogr. Ephem., p. 91) and the following:

### Atalophlebia Fulvipes sp. n.

Male—Length of body 12 mm., of wing 13 mm., of tails 13 mm.

Color brown, becoming yellowish beneath. Eyes above testaceous, the lower division black. Prothorax with a narrow blackish collar. Mesothorax brownish fulvous, darker around the sides and at the front, and showing a faint mid-dorsal yellowish stripe. Legs tawny yellow; fore legs wanting; middle and hind femora with a brownish ring just beyond the middle and with darker tips. Wings

hyaline, with a very faint tinge of fulvous at the costal strip, whose veins are brown, with the humeral cross vein blackish. Venation as shown in pl. 8, fig. 96.

Abdomen obscure but paler and translucent on middle segments; color pattern not preserved; segments 9 and 10 darker.

Forceps (pl. 8, fig. 98) rufous and penes yellowish. Tails fulvous, constricted on second segment, and faintly ringed by darker color toward tip of succeeding segments.

One male from Butalcura on Chiloe Island, Chile, August 5, 1920, collected by Dr. J. C. Bradley.

Holotype, C. U. No. 634.

### Nymphs

We have had for study some well preserved alcoholic specimens of nymphs from Argentina, the venation of whose developing wings shows rather close correspondence with that of *A. chilensis* as figured by Eaton (Rev. Monogr. Ephem., pl. 10, fig. 16g). They may be described as follows:

*Atalophlebia sp?* nymph—Length of body 11 mm., tails 11 mm., additional.

Color greenish brown, darkest on dorsum of thorax and abdomen; paler on the face, on the sides of the prothorax, and on the entire lateral margin of the abdomen; in the male the dorsum of abdominal segments 4 and 5 and 8 to 10 are paler than in the female. Antennae pale with blackish tips. Tails pale with the joinings of a few of the basal segments narrowly ringed with brown. Legs (pl. 9, fig. 118) pale, with a streak of brownish on the middle of the external face of each femur. The femora bear among the hairs of their upper surface several lines of small and inconspicuous blunt-tipped spinules. Each claw (pl. 9, fig. 119) bears underneath a row of about a dozen minute denticles. Head and mouth parts are as shown in pl. 9, figs. 105, 110, 111 and 121.

The gills are double, long-lanceolate, very slowly tapering, with dense pinnately arranged, purplish, main tracheal branches, that are several times dichotomously branched in each division of the gill plate, and that give color to the gills quite to their tips.

Nine well preserved nymphs from Puenta del Inca, Argentina, 3,300 meters altitude, March 22, 1910.

## ATALONELLA GEN. NOV.

This genus is established to include two small species from Chile, one of which, *A. fusca* (Ulmer, Arch. f. Naturg. 85:20), has hitherto been included in Atalophlebia, and the other of which, *A. ophis,* is described herewith as new. The nymph corresponding to the latter is also described herewith. Both nymphal and adult characters seem to separate these forms clearly from typical Atalophlebias. The venational distinctions are stated comparatively as follows:

FORE WING

| *Characters* | *Atalophlebia* | *Atalonella* |
|---|---|---|
| Costal cross veins in the basal half of the subcostal space | Numerous | Wanting |
| Costal cross veins of the stigmal region | Erect | Aslant |
| Bisector of the cubital fork at its proximal end | Nearer to the first anal vein | In middle of the fork |
| Second anal vein | Straight in its apical third | Curved all the way to the tip |

HIND WING

| *Characters* | *Atalophlebia* | *Atalonella* |
|---|---|---|
| Tip of subcostal vein at | Nine-tenths of wing length | Three-fourths of wing length |
| Upper fork of median vein | Normal, attached | Disconnected at base |
| Bisector of lower fork of median vein | Present | Absent |
| Cross veins between the anal veins | Present | Absent |

The differences in nymphal characters may be stated comparatively as follows:

NYMPHS

| *Characters* | *Atalophlebia* | *Atalonella* |
|---|---|---|
| Lateral spines on abdominal segments | 5 to 9 | On 9 only |
| Femora | Dilated | Slender |
| Distal tooth under tarsal claw | Minute | Excessively large |
| Width of labrum exceeds length | Three times | Two times |
| Glossae of labium at tips | Conic-pointed | Widened |

### Atalonella Ophis sp. n.

Male—Length of body 7 mm., of wing 7.5 mm., of tails 10 mm., of fore leg 9.5 mm.

Color deep rich brown, darkest on eyes and on top of mesothorax. Prothorax with a narrow dark nuchal line; balance of thorax all brown, paler only on the sutures and beneath. Legs pale translucent yellowish, a darker touch upon the knees shows on middle and hind legs more plainly because these are paler than the fore legs. No bands on femora. Wings hyaline and iridescent with a duller but hyaline costal strip and a brown humeral cross vein. Venation as shown in pl. 8, fig. 97.

Abdomen brown, wholly so at ends, and across apex and sides of middle segment, each of which is invaded by an obscure paler triangle and a pair of lateral subapical round spots. Forceps (pl. 8, fig. 101) and penes yellow, the former brown at base externally. Tails nearly concolorous pale, faintly ringed about the joinings of the short basal segment.

Many specimens, all males from Butalcura, Chile, April 4, 1920, collected by Dr. J. C. Bradley. Holotype, C. U. No. 635, mounted on a slide.

This species is near to *A. fusca* Ulmer in size and in venation, but differs in color pattern of legs and abdomen, and in form of genitalia.

### Nymph

To this genus is referred a Chilian nymph corresponding in size with *A. fusca,* which is very closely related to *A. ophis.* Its hind wing (see pl. 9, fig. 113) agrees fairly well with the hind wing of the latter species (pl. 8, fig. 97a); therefore, though not proved, the reference to this genus seems safe. It may be described as follows:

### Atalonella sp? (Supposition) Nymph

Length of body 6 to 7 mm., tails broken.

A pale greenish brown nymph with broad depressed linear body and broad pale femora. Head and thorax obscurely mottled, a little darker at the lateral margins. There are pale spots before each ocellus and also on the rear of the head. Mouth parts, as shown in pl. 9, figs. 106 and 112.

Abdomen obscure; in the paler specimens there appears a double row of inverted U-spots, a pair on each segment, each opening to the rear. In darker specimens the brown overspreads the dorsum leaving sometimes a row of pale spots each side (the portion within the U-spots), and a mid-dorsal streak. Gills purplish, lanceolate in outline with acuminate tips and rather coarsely pinnate tracheation.

The lateral spines on abdominal segments 5 to 9 are short and triangular in front and become longer and sharper on successive segments, on segment 9 being about as long as the body of that segment, and closely appressed to the sides of segment 10. The prolonged sternite of 9 is produced backward in a long and wide triangular lobe, obtuse at tip, and surpassing the tenth segment by the length of that segment.

Each tarsal claw (pl. 9, fig. 107) has a few minute denticles underneath in a series that abruptly terminates in a denticle so long that it simulates a fork with the tip. Fore leg as shown in pl. 9, fig. 108.

Numerous specimens in alcohol (not very well preserved) from Puerto Varas, Chile, April 8, 1920, collected by Dr. J. C. Bradley.

# (?) DELEATIDIUM

Three species of nymphs having some relationships with the two preceding genera are before us, none of them in proper condition for the study of the venation. All come from Chile. They are doubtfully referred to the two remaining allied genera that are now known from Chile. Two large species, having long sharp lateral spines on abdominal segments 8 and 9 are referred to Deleatidium, and the third, a small species having short triangular lateral spines on these same segments, to Nousia. These nymphs, though quite different in size, and all apparently well grown, agree well in color pattern and in form. The front border of the broad labrum is widely emarginate, and broadest across the anterior portion. The lanceolate gills terminate in long tapering points. One nymph is too large to belong to any described species of Deleatidium; the two referred to that genus may be distinguished by size as follows:

1—Length of body 16 mm........................Deleatidium Nymph No. 1
—Length of body 11 mm........................Deleatidium Nymph No. 2

### (?) Deleatidium Nymph No. 1

Length of body 16 mm., tails 10 mm., additional.

A stout bodied brownish nymph with dilated and brown-banded femora, and stout bare tails and antennae.

The general brownish color includes some marmorate paler areas upon the thorax. A triangle of paler spots on the head, one before each ocellus, a pair on the clypeus, a narrow median line on the occiput, and a generally paler color on the dorsum of the middle abdominal segments leaving, besides brown lateral and apical margins to the segments, two parallel rows of brownish spots, the outer darker and less interrupted. Tails and antennae are pale brown. The lateral spines on the abdomen are like those shown in pl. 9, fig. 115.

Ten nymphs from Butalcura, Chiloe Island, Chile, April 5, 1920, collected by Dr. J. C. Bradley.

### (?) Deleatidium Nymph No. 2

Length of body 11 mm., tails 5 mm., additional.

Very similar to the preceding, especially in distribution of the pale spots on the head; but on the middle abdominal segments there is a median basal pale spot, and there are two additional mid-lateral ones on each side of each segment. The lateral margin of the abdomen is not darker than the general ground color. The lateral spines on the abdominal segments are as shown in pl. 9, fig. 115.

A dozen or more poorly preserved alcoholic nymphs from Puerto Varas, Chile.

## (?) NOUSIA

The nymphs herewith doubtfully referred to this genus differ from the two last preceding chiefly in having short flat triangular lateral spines on abdominal segments 8 and 9 (pl. 9, fig. 120), and in their smaller size.

### (?) Nousia Nymph No. 1

Length of body 7 mm., tails broken off and lost.

Color obscure greenish with very numerous narrow brown markings all over the dorsal surface, but defined on the top of the thorax. The spots on the face are arranged as in the two preceding species. The brown of the abdomen tends to form two submedian and two mid-lateral longitudinal lines. The broad femora show obscure clouds of fuscous on the outer face. A pale specimen shows on the mesothorax two small brown U-marks on the front margin, opening backward, and opposed to a brown W-mark behind.

Ten specimens from Butalcura, Chiloe Island, Chile, April 5, 1920, collected by Dr. J. C. Bradley.

## HERMANELLA GEN. N.

This genus is based on two nymphs from Chile of very unique character. One of these nymphs shows venation in its wings completely enough to allow the genus to be characterized thereby; for it is an unique venation. Fore and hind wings are shown in pl. 10, fig. 133. In the fore wing there are numerous costal cross veins; both principal median forks are well outward in the wing and the rear one is oblique, strongly askew to rearward, as is also the deep cubital fork. The basal half of the latter fork lacks cross veins, the bisector of the fork being but half its length. The two long intercalaries between first and second anal veins hardly differ in appearance from these veins and are conjoined by many erect cross veins. The apex of the hind wing is eroded at the front beyond a low costal angulation and no cross veins are visible in the costal or subcostal spaces before this angulation. The first median fork is strong and contains two equal intercalaries, conjoined by two cross veins, and behind the fork are two additional long veins conjoined by a single cross vein.

The nymph of this genus is a grotesque-looking little black creature, strongly depressed, with a big, flat, squarish head that appears almost as large as the thorax, stout spiny legs, an abbreviated abdomen and very long tails. The enormous maxillary palpi stick out like elbows beyond the sides of the head, the elongated white second joint showing conspicuously alongside, and the copious brown brushes of long plancton-gathering bristles that clothe the last segment

showing more or less, according to their extension, at the front. The ample wing sheaths of the nymph well nigh cover the abbreviated abdomen, functioning as opercula for the gills which they completely conceal.

Type, the following species:

### Hermanella Thelma sp. n.

Length of body of nymph 4 mm., middle tail 6 mm.

Color blackish brown above, pale beneath. There are cloud-like pale spots at sides of head and of prothorax in front and at base and apex of femora, and there are dark rings on the pale tibiae and tarsi. Details of structure are illustrated in the figures of plate 10. There are lateral spines on the eighth and ninth abdominal segments and the ninth in the female is produced on the ventral side beyond the apex of the tenth segment, and bifid at the tip, where it terminates in a pair of triangular points. Tails rather bare, and faintly ringed with darker color at the closely set joinings of the segments. The upper division of the eyes of the male nymph are reddish brown, and only partially cover the black annular lower division.

Two specimens from Iguazu Falls, Argentina, January 25, 1920, collected by Dr. J. C. Bradley.

Holotype, C. U. No. 636, mounted on slides.

## THRAULODES

This genus of ornate little mayflies is abundantly represented in Neotropical America. To the ten species hitherto described we add two new ones from Peru. We are able to describe also a nymph of this genus.

### Artificial Key to the Imagos

| | | |
|---|---|---|
| 1— | Large species (wing 15 mm.), legs brown, not banded nor striped...... | 2 |
| — | Smaller species (wing 11 mm. or less), legs mostly banded or striped.. | 3 |
| 2— | Color light brown....................................*columbiae* | |
| — | Color rufous ........................................*nervosa* | |
| 3— | Species of intermediate size (wing 8 to 11 mm.).................. | 4 |
| — | Species of the smallest size (wing 7 mm.)........................ | 9 |
| 4— | Legs plain brown, tips of tails black........................*lepidus* | |
| — | Legs banded or streaked with brown.............................. | 5 |
| 5— | With lengthwise stripe on femora............................*valens* | |
| — | With brown rings on femora...................................... | 6 |
| 6— | Legs with a single ring of brown................................ | 7 |
| — | Legs with two rings of brown.................................... | 8 |

7—Top of mesothorax plain yellowish brown...............*telegraphicus*
—Top of mesothorax having a shield-shaped field that is sharply defined by angulate brown lines.................................*plicatus*
8—Spots on lateral margin of abdominal segments single..........*laetus*
—Spots on lateral margin of abdominal segments in threes....*bomplandi*
9—Thorax grayish black..................................*vitripennis*
—Thorax brownish ............................................. 10
10—Thorax yellowish brown...............................*lepidus*
—Thorax blackish brown................................*mexicanus*

### Thraulodes Telegraphicus sp. n.

Male—Length of body 9.5-10 mm., of wing 11-11.5 mm., of tails 25 mm.

Female—Length of body 8.5-9.5 mm., wing 11-11.5 mm.

Colors yellow and brown. Upper eye of ♂ red brown. Basal segment of antenna rufous, surrounded by a rufous ring that is again surrounded by a yellow ring. There is a yellowish median spot between the ocelli, and another lies upon the clypeolabral border. Prothorax yellow, with a narrow brown line running obliquely downward to the base of the fore leg. The mesothorax is fawn-yellow with brownish trimmings; the crest at its rear is brown in the middle and yellow at the sides. The more convex of the ventral surfaces are broadly washed with pale brown.

The wings are hyaline, with yellowish venation and an arcuate basal brown spot runs from the humeral cross vein backward in both wings. The venation is as shown in pl. 8, fig. 99.

The legs are yellowish, with a wide subapical brown ring on the femora, proximal to which the outer face has a fawn yellow area bordered with brown. Tibiae and tarsal segments are marked with brown at the tip, the latter more faintly.

The abdomen in the male is brown at both ends above, and translucent whitish in segments 2 to 6—so translucent that the spots of the opposite side show through. There is a row of roundish brown spots on the lateral margins of segments 2 to 7, elongated to broad dashes on segments 8 and 9, and there is a second row of similar spots midway of the sides on segments 2 to 6. The dorsum of segments 7 to 10 is a rich chestnut brown color bordered laterally by whitish, the brown deepening in intensity but narrowing in width to the rearward. The abdomen in the female has similar lateral markings, but dorsally there is a median brown band that descends to sides at base of the segments in tracts that increase in breadth to rearward. In old females the pale areas at the sides become chalky white and contracts beautifully with the rich red brown of the dorsum. The humeral cross vein also reddens with age.

The tails beyond their yellowish extreme basal segments, are conspicuously ringed with black and white, not in alternate segments, but irregularly, forming dots and dashes (suggesting a telegraphic message, whence the specific name). Forceps of the male (pl. 8, fig. 102) brownish externally on the basal half.

A very beautiful species, near to *Th. laetus* from Colombia.

Four specimens, one imago and one subimago of each sex, from Campamiento, Colony of the Perené, Junin, Peru, June 28, 1920, collected by Dr. J. C. Bradley. One additional male bears date of June 27th.

Holotype, C. U. No. 637, mounted on a slide.

### Thraulodes Plicatus sp. n.

Male—Length of body 8 mm., of wing 10 mm.

Female—Length of body 10 mm., of wing 9.5 mm.

Color yellowish with a shield-shaped area on the top of the mesothorax outlined in angulated fuscous lines. Head blackish. Abdomen yellowish, becoming rufous toward the tip in the male or yellow in the female. Prothorax broad, laterally expanded at the front in epaulet-like lobes that are narrowly edged with black. The disc of the mesothorax bears a median pale line that is expanded to form a double hook at the front end, and that runs rearward out of the shield-shaped area to a yellow spot upon the crest. The sides of the thorax bear faint touches of brown about the bases of the legs.

The wings (pl. 8, fig. 100) are hyaline, with a fuscous spot crossing the veins Sc and R at the humeral cross vein. The legs are yellowish with an obscure band of brown beyond the middle and a touch of brown externally at the knees. There is a much darker and more distinct brown spot at the apex of the tibia. Front feet of male, missing; of female, white.

The abdomen in the male is translucent whitish on segments 2 to 7, and not distinctly annulate, though paler at the joinings of the segments; there is a mid-lateral roundish brown spot each side and another smaller one below this at the stigma; on segments 8 and 9 there is a blackish dash along the lateral margin. Segment 1 is brownish at the sides and segments 9 and 10 are rufescent dorsally. In the female the abdomen is transversely banded with brown, the joinings of the segments being whitish. The brown is restricted to the base at the sides, and in the paler area stigmatic spots appear as in the male. The sides of segment 1 are blackish, and the dorsum of the apical segments is whitish or yellowish. Only the bases of the broken tails are present; in these the segments increase rapidly in length and the broken rings at their tips increase in width proportionately.

One male imago (the type) and one male subimago, El Campamiento, Colony of the Perené, Junin, Peru, June 20, 1920; also two female subimagos,

Puerto Bermudez on the Rio Pichis, Peru, July 11 and 19, 1920, J. C. Bradley collector.

Holotype, C. U. No. 638, two wings and genitalia on slides, the remainder in alcohol.

### The Nymph

The nymphs here referred to Thraulodes and those described under the two following generic names, are much more closely related to each other than were those of the three preceding genera. The three rather closely agree in the following diagnostic characters:—

1. Lateral spines with eroded tips on abdominal segments 2 to 9.
2. Labrum pointed at ends, not notched in the middle in front.
3. Last joint of labial palpus minute.
4. Glossae of labium, semi-elliptical, inner margin straight.
5. The rearward projecting triangular lobe of the ninth abdominal sternite is notched at the tip.

Unfortunately, the venation of the wings is not well preserved in any of them. Only in the first described have we been able to make out the single point that the median fork of the hind wing is present; hence its reference to Thraulodes.

To the genus Thraulodes we refer two nymphs from Peru having the gills graduated in size and becoming smaller to rearward, on the basis of the venation of the hind wing, which, though poorly preserved, yet shows a well developed posterior fork, such as is characteristic of Thraulodes. The nymph may be briefly characterized as follows:

### Thraulodes sp? Nymph

Length of body 10 mm., tails 10 mm., additional, antennae 5 mm.

Color above uniform brown, with only faint touches of paler on the top of the thorax, and no discernible pattern on the abdomen. Form strongly depressed with a broad squarish head. The postero-lateral spines on the abdomen have exteriorly eroded tips as shown in pl. 9, fig. 123.

Two nymphs from Eneñas on the Camino del Pichis in the Cerro de Sal, Junin, Peru, July 4, 1920 (altitude 1,401 meters), collected by Dr. J. C. Bradley.

## HAGENULOPSIS

A single nymph from Peru is doubtfully referred to this genus. There is no venation discernible in its wings, owing to bad preservation, and the reference to this genus is based solely on the fact that it has no hind wings, and that

Hagenulopsis is the only known South American genus of Thraulus allies that has this character; all the others have two pairs of wings. It may be briefly characterized as follows:

### Hagenulopsis sp? Nymph

Length of body 4 mm., tails 11 mm., additional.

A curious, little, flat, long-tailed nymph of pale greenish-brown color that is hardly varied with paler in a few mottled areas on top of head and thorax. Abdomen with transverse darker line across the apical margin of its segments, and with spots of same at sides of middle segments. Legs blackish, fringed externally with scurfy brownish hairs.

One nymph: Eneñas on the Camino del Pichis, Junin, Peru, July 4, 1920.

## THRAULUS

Of the five described neotropical species of this genus of delicate mayflies, two are represented in the collections made by the Cornell University Entomological Expedition: *T. missionensis* and *T. valdemari,* both from Argentina, the latter from Rio Alta Parana. To these five we add two new species. The seven may be separated by the key given below.

The nymphs here referred to this genus do not agree well with those of European *T. bellus* as described and figured by Eaton. (Rev. Mongraph. Ephem., pl. 35) especially in the form of the gills, but are more like those than like any other known forms. Unfortunately none of the nymphs was positively determinable.

### Key to the Neotropical Species of Thraulus.

1—With two brown rings on each femur, and a brown costal strip on fore wing ........................................ *ehrhardti*
—With not more than one brown femoral ring........................ 2
2—With an arcuate brown band across the base of both wings...... *bradleyi*
—With no arcuate brown band across the base of both wings........... 3
3—Tails ringed with brown........................................ 4
—Tails not ringed with brown.................................... 6
4—Legs blackish; basal half of wings yellowish.................. *primanus*
—Legs yellowish; basal half of wings not yellowish.................. 5
5—Wings marked with brown on cross veins................ *maculipennis*
—Wings hyaline not with brown on cross veins............ *missionensis**

* New figures of venation and genitalia of this species are shown in Pl. 11, figs. 139 and 144.

6—Legs brown .......................................... 7
—Legs yellow, with a brown ring on the femur................*maculatus*
7—Thorax dark brown; wing length 7.5 mm....................*valdemari*
—Thorax light brown; wing length 11-12 mm.................*versicolor*

### Thraulus Bradleyi sp. n.

Male—Length of body 7 mm., of wing 6.5 mm.

Female—Length of body 6.5 mm., of wing 7 mm.

Color of the male imago rich red brown, only the bordering carinae of the thoracic segments narrowly bordered with blackish. Legs lost. Wings hyaline; both fore and hind wings with an arcuate brown spot covering the base at the level of the humeral cross vein; bases of the stronger veins yellowish. Venation as shown in pl. 11, fig. 137. Abdomen brownish above on the base of the first segment, whitish translucent on segments 2 to 6, with bands of brown across the apices, increasing in width to rearward; segments 7 to 9 brownish, and segment 10 paler. Tails broken off and lost. Genitalia of male as shown in pl. 11, fig. 142.

The male subimago is similar, with colors fainter.

The female has the head yellowish above with a flexuous fuscous band across the ocelli, another across the front border of the prothorax. There are narrow fuscous lines before the roots of the fore wings, and on the sides of the dorsal crest at the rear of the mesothorax. There are transverse bars of brown covering the dorsum of segment 1 of the abdomen, and faintly overspreading segments 2 to 5, divided with paler by a narrow median line.

One male imago and one female subimago from Rio Alta Parana above Posadas, Argentina, January 18, 1920; also two ♂ and one ♀ subimagos from Paraguay River, Brazil, December, 1919.

Holotype, male imago, C. U. No. 641, wings and genitalia mounted on slides.

### Thraulus Maculatus sp. n.

Male—Length of body 5.5 mm., of wing 5.5 mm., of tails 6 to 8 mm.

Color brown. Eyes black in the lower, red in the upper division. There are rings of black about the ocelli and about the bases of the yellow antennae. Thorax wholly brown, only a little paler below, especially about the bases of the legs. Legs whitish, faintly tinged with brown, with obscure subapical rings on the femora, that are most evident on the hind legs. Wings hyaline, with only the bases of a few of the stronger veins yellowish. Venation as shown in pl. 11, fig. 138.

Abdomen brown above with yellowish spots; the larger of these form a row of right triangles on each side, with their inner margins forming an interrupted

longitudinal line, and their outer margins (hypothenuse) resting on the serrated lateral border of brown. There is also a pair of small more dorsal roundish basal spots on each of the same segments, with a very narrow pale median line dividing the brown between them. Tips of forceps (pl. 11, fig. 143) white. Tails white.

Many male specimens from two localities in Argentina, Cosquin, and Santa Fe.

Holotype, male imago, C. U. N. —.

The smallest species of the genus, near *missionensis* Peterson.

### Thraulus Nymph No. 1

Length of body 10 mm., of which the head comprises nearly 2 mm., tails broken.

Color dark brownish above, mottled with paler. There is a pale sinuate line from eye to eye before the ocelli and there are other fine pale lines on the face. A narrow pale mid-dorsal line traverses pro- and mesothorax, on the latter accompanied by two others out-curving toward the front of the segment. On the disc of pro- and mesothorax are also some obscure paired paler areas. The joinings of the abdominal segments are brownish, the lateral margins, and a pale wash across the apex, and all of the tenth segment being paler.

The venation of the nymphal fore wing is very imperfectly preserved (of the hind one, not preserved at all); it shows the weak cross veins of the stigmal region very oblique but not conjoined. It shows the rear fork of vein M at midway the length of the wing. It shows a rather wide cubital fork, deeper than the preceding fork, and skewed considerably to the rear.

Numerous specimens Eneñas on the Camino del Pichis in the Cerro de Sal, Junin, Peru, altitude 1,491 meters.

### Thraulus Nymph No. 2

Length of body 7 mm., tails broken.

A broadly depressed, squarish headed, brown nymph with narrowly lanceolate double gills. Color brown. Head with a blackish spot between the ocelli that is surrounded in front by a paler area. Prothorax brownish with a paler area on each side of the disc. Mesothorax brownish obscurely mottled with paler. Abdomen brown with darker bands across the apical margins of the segments and an interrupted longitudinal line traverses them on each side. Base of (broken) tails is brownish, but the legs are paler.

The fore wing of the nymph shows the following features: There are rather numerous cross veins in the basal half of the costal space. The posterior division of the median vein is a little askew to rearward at its fork. There are two short intercalaries on a common stalk between the first and second anal veins,

and attached to the former, with no cross veins showing in this area.

Numerous alcoholic specimens from Tambo Miriatiriani on the Camino del Pichis, Junin, Peru, July 9, 1920.

### (?) Thraulus Nymph No. 3

Length of body 7 to 8 mm., tails broken and lost.

Color greenish brown. A pale arcuate area in front of ocelli, and rear of head paler, especially next the eyes. Three nearly contiguous pale clouds extend across the rear of the prothorax. Front femora pale, showing two faint bands of brown, the proximal one incomplete.

Abdomen pale, with brownish bands across the apices of the segments; these narrow and complete on segments 8, 9 and 10, wider on segments 4 to 7, and interrupted in the middle and expanded at the sides, on the basal segments. Gills lanceolate pale with the larger middle tracheae pale purplish.

Four specimens from Tambo Miriatiriani on the Camino del Pichis, Junin, Peru, July 9, 1920.

## CHOROTERPES

To the single described neotropical species of this genus we add descriptions of two new ones. The three may be separated as follows:

1—Size small (wing 5 mm.)........ ........................*ermersoni*
—Size larger (wing 7-9 mm.)..................................... 2
2—Thorax black above..........................................*inornata*
—Thorax yellow above with two black stripes..................*bilineata*

### Choroterpes Emersoni sp. n.

Male—Length of body 4 mm., of wing 5 mm., tails 10 mm.

Female—Length of body 4½ mm., of wing 5 mm.

Color reddish brown deepening to black on the head, with hardly any pattern. The abdominal segments are lineate with blackish across the dorsal apical margins of the segments and along the lateral carinae. Tails yellow, the joinings of the segments narrowly marked with brown. Wings hyaline, obscurer along a costal strip, especially in the stigmatic area of it. Venation as shown in pl. 11, fig. 141. Legs yellowish, the front femora brownish as are also the tips of the tibiae. There are also faint submedian and apical brownish clouds on the femora of middle and hind legs.

The male forceps (pl. 11, fig. 145) are brown externally. In the female the tenth abdominal ventral segment is produced to rear into a triangular lobe as

long as the body of the segment and bifid at the tip. The seventh segment is produced to rear in a long triangular ovipositor (see pl. 11, fig. 146) whose tip is on a level with the tips of the tenth segment.

Male and female specimens from Kalacoon, Bartica District, British Guiana, collected by Alfred E. Emerson on March 23, 1918.

Holotype, C. U. No. 639, wings and genitalia mounted on slides.

They were collected from spiders' webs that overhung Kalacoon brook. In the same brook were found nymphs that appear to belong to this species. They differ from the nymphs of this genus hitherto made know (in Europe and North America) by the shape of the gills. These in the Kalacoon species are double, lanceolate and smoothly tapering to long slender tips, not at all notched or lobed.

### Choroterpes Bilineata sp. n.

Male—Length of body 6.5 mm., of wing 7 mm.

Female—Length of body 7 mm., of wing 9 mm.

Color pale yellowish, with two dorsal blackish stripes extending from head to tail, blackest on the prothorax, widest apart on the mesothorax and becoming confluent on the apical segments of the abdomen. No other markings except on the wings, which have a regular costal strip of yellow or fawn color with brown overspreading a few cross veins in the stigmatic region. Humeral cross vein deep blackish brown. Membrane of the wings hyaline and iridescent; veins yellowish. Venation shown in pl. 11, fig. 140.

Two male subimagos from Rio Putumayo, Peru, August 14, 1919.

Five females, La Chorrera, Putumayo Distr., Peru, August 16, 1919, collected by Dr. J. C. Bradley.

Holotype, female, C. U. No. 640-1, wings mounted on a slide, the remainder in alcohol.

A handsome and very distinct species.

## CALLIBAETIS

An American genus, abundantly represented in both continents, containing species of moderate size and of very beautiful coloration. A few species are wholly pale, but the wings of most species are marked with brown in very ornate patterns. There are differences between the sexes in depth of coloration, and often great differences between imago and subimago in the extent of it. The following key, being based largely on published descriptions of imagos, is not to be trusted too far; careful reference must be made to original sources.

Nymphs of this genus have been described and figured by the senior author in N. Y. State Museum Bull. 68; 216-217, pl. 7.

## Key to Neotropical Species; Imagos

1—Wings colored .................................................... 2
—Wings hyaline .................................................... 14
2—Brown of the wings, diffuse.................................... 3
—Brown of the wings mainly confined to a costal strip covering the three veins C, Sc and $R_1$.................................... 9
3—Brown of the wings fenestrate, by hyaline areas surrounding cross veins ....................................*apertus*
—Brown of the wings in oblique cross bands separated by hyaline area that follows lines of cross veins.............................. 4
4—Hyaline areas, rather narrow bands.............................. 5
—Hyaline areas broader, the intervening brown bands more or less interrupted or scattered.................................... 8
5—Short intercalaries over most of the hind margin of the fore wing single or wanting.................................... 6
—Short intercalaries over most of the hind margin of the fore wing in pairs .................................................... 7
6—Costal area of fore wing fenestrate with hyaline on the cross veins ....................................*trifasciatus*
—Costal area of the fore wing uniformly tinted...............*sellacki*
7—Wing three times as long as wide; brown bands very oblique, parallel to the hind margin; cross veins numerous, in three rows..*fasciatus*
—Wing two and a half times as long as wide; bands more transverse; cross veins fewer in incomplete, indistinct rows...........*jocosa*
8—Brown dispersed across the wing apex.......................*apicatus*
—Brown extended across the middle of the wing.............*guttatus*
9—Pale brownish markings extend rearward from the apex of the colored costal strip around the distal portion of the hind border.....*pictus*
—No such markings behind the costal strip.......................... 10
10—Costal strip broken into spots between paler areas in its middle portion; hind wing with about two cross veins behind its costal area..*zonalis*
—Costal strip not wholly interrupted by its paler markings; cross veins of hind wing numerous.................................... 11
11—Intercalaries of hind wing between second and third long veins, distinct ....................................*jaffueli*
—Intercalaries of hind wing indistinct or wanting.................. 12
12—Base of hind wing tinged with brown.............................. 13
—Base of hind wing hyaline....................................*viparius*
13—Basal half of costal space with cross veins.................*montanus*
—Basal half of costal space with no cross veins...............*viviparus*

14—Hind wing with short intercalaries between the second and third long veins .................................................... 15
—Hind wing with no intercalaries between these veins.........*abundans*
15—Color of thorax pale yellow; wing length 5.5 mm..............*pallens*
—Color of thorax piceous; wing length 7.8 mm.................*vitreus*

### Callibaetis Viviparus sp. n.

Female—Length of body 8.5 mm., wings 7.5 mm.

Color yellowish, besprinkled with dots of purplish brown. A wide dorsal band of pale brownish color begins on the head (where separated from the eye on each side by a longitudinal pale line) and continues on the thorax (where divided by a pale line and narrowly interrupted on the rear margin of the prothorax by another transverse one), darkest in color on the front of the mesothorax and becoming obscure on the abdomen. Antennal segments 1 and 2 ringed with brown, 2 more broadly.

Wings with a distinct costal band of brown fenestrate (with hyaline as shown in pl. 12, fig. 152) in the places where costal cross veins normally occur (these, however, being very faint or wanting). The band is traversed by about ten simple oblique costal cross veins in the region of the stigma. Base of radius blackish, as are the cross veins in the base of the subcostal space; these latter occur in more or less irregular groups surrounded by hyaline spots. A few paler cross veins are similarly surrounded in the subcostal space at beginning of the stigma, and behind these are two other similar, rather more conspicuous clear spots, that widen to rearward, covering the cross veins in the first radial space and overlapping the first branch of the median vein. The brown costal strip overspreads vein $M_1$ a little at the wing apex, and again at the base where it extends rearward upon the anal arc. The hind wing is hyaline. There is an oblong axillary spot of deep brown color on the thorax underneath the base of the fore wing.

There are roundish brown spots both above and below the stigma on each side of abdominal segments 2 to 9, these mostly double, a large portion above a smaller one. Sides and venter of abdomen and of thorax thickly sprinkled with dots of bright purplish color. Legs pale, with faint brown touches on the joinings of the segments. Tails lost.

Three female specimens, all imagos, from Corumbá, Brazil, December 14, 1919.

Holotype, C. U. No. 643, mounted on a slide.

This handsome species is near *C. montanus,* but differs by the characters given in the key. The eggs in these females contained well developed embryos as indicated in figure 154 of pl. 12. Hitherto *Cloeon* in Europe is the one

ephemerid known to be viviparous, while *Ameletus ludens* in North America is the only one known to be parthenogenetic (Morgan, Ann. Ent. Soc. Amer. 4; 117, 1911).

### Callibaetis Pollens sp. n.

Male—Length of body 5.5 mm., wing 5.5 mm., tails 10 mm.

Female—Length of body 6 mm., wing 5.7 mm.

Color wholly pale yellow with an amber tint on the upper eyes of the male and on the second joint of the antennae; lower division of eyes black. There are several faint rings on a few basal joinings of the tails of the male, and a female subimago shows a double row of blackish sub-spiracular spots on the abdomen in segments 3 to 9.

Wings hyaline; veins white; venation as shown in pl. 12, fig. 147; forceps of the male as shown in pl. 12, fig. 162.

A male imago and a female subimago from Corumbá, Brazil, December 14, 1899, collected by Dr. J. C. Bradley.

Holotype, male, C. U. No. 644, mounted on slides.

### Callibaetis Jocosa.

This species appears to be represented by a single female imago from Paraguay River above Porto Esperança, Brazil, collected in December, 1919. Since it is somewhat smaller in size (length of body 6.2 mm., wing 5.5 mm.), and does not quite agree in details of color it is referred here doubtfully; but its venation agrees with that of *C. Jocosa* as figured by Navas in *Brotéria* 10; 196.

## BAETIS

This cosmopolitan genus of small mayflies is well represented in South America. To the half dozen species hitherto described we add four new ones. A still larger number of species were obtained as nymphs by the Cornell University Expedition, and three of these that show differences from the nymphs of the genus hitherto made known in Europe and North America, are described in the following pages.

### Key to the Species—Imagos

1—Hind wings with three longitudinal veins.......................... 2
 —Hind wings with two longitudinal veins.......................... 6
2—The second of these veins forked.......................... 3
 —The second of these veins simple.......................... 5

3—Fore wings with a brownish costal band ........................ *salvini*
—Fore wings hyaline ........................................ 4
4—Hind wings with cross veins ........................ *peruvianus*
—Hind wings with no cross veins ........................ *comes*
5—Costal angle of hind wing obtuse ........................ *opacus*
—Costal angle of hind wing acute ........................ *melleus*
6—Second vein of hind wing forked ........................ *socius*
—Second vein of hind wing simple ........................ 7
7—Veins of hind wing convergent to wing apex ........................ 8
—Veins of hind wing parallel toward wing apex ........................ 9
8—Hind wing broad, its veins meeting margin before the wing apex ... *virellus*

### Baetis Melleus sp. n.

Male—Length of body 5.5 mm., wing 4.5 mm.

Female—Length of body 4.5 mm., wing 5 mm.

Color honey yellow slightly paler beneath. There are some faint broken lines of brown on the thoracic carinae and about the wing root. The upper division of the eyes in the male is amber brown.

The middle segments of the abdomen of the male are translucent whitish; along the sides of the abdomen black sooty lines of pigment on the tracheae show through the skin. Legs and tails pale. Wings hyaline. There are strong costal cross veins in the region of the stigma. Hind wing flabellate, with a prominent costal angulation and veins as shown in fig. 148, of plate 12. The form of the forceps of the male is shown in pl. 12, fig. 158.

One male Santa Fe, Argentina.

Holotype, C. U. No. 645, mounted on slides.

Two females, La Chorrera, Putumayo District, Peru, August 16, 1920, collected by Dr. J. C. Bradley.

### Baetis Socius sp. n.

Female—Length of body 8 mm., of wing 8 mm.

Color pale brown, yellow on head, on the tenth abdominal segment, on legs and on tails. There is a brown transverse line on the collar abutting the rear of the head interrupted in the middle. There is a vertical dark brown line at the front of the mesothorax each side, and another oblique narrow one before the wing roots. There are some pale yellow streakings on the prothorax. A very narrow median pale line and three wider oblique ones converge rearward upon the crest of the metathorax where a pale spot is inclosed by two unequal transversely placed ( )-marks, the smaller in front, the larger behind. Abdomen

with dark brown lines across the apices of segments 2 to 10. There is a small obscure median T-spot on the base of segments 2 to 9, with a pair of small round dots close behind it.

Wings of a uniform pale brownish with veins indistinctly showing slightly paler. Venation as shown in pl. 12, fig. 153. Bases of legs and tails pale; tips broken off.

One ♀ subimago, Huacapistana on the Rio Tarma, Peru, June 1-3, 1920.

Holotype, a female, C. U. No. 646, wings mounted on a slide, remainder in alcohol.

Near *B. comes*, but larger and with a different sort of hind wing.

### Baetis Tantillus sp. n.

Female—Length of body 4 mm., of wing 3 mm.

Color pale brown above with abdomen paler beyond its basal segment. There are some darker narrow arcuate lines about the borders of the mesothorax above. All else is pale, including legs and antennae. Wings hyaline, slightly milky at the stigma. Venation as shown in pl. 12, fig. 157.

Two females, La Chorrera, Putumayo District, Peru, August 16, 1920.

Holotype, C. U. No. 647, wings on a slide, the remainder in alcohol.

This species is allied to *B. inops* and *B. dryops*, but is smaller, and has two parellel longitudinal veins in the hind wing and also some traces of cross veins.

### Baetis Dryops sp. n.

Male—Length of body 4.5 mm., of wing 5 mm.

Female—Length of body 5 mm., of wing 5.5 mm.

Color amber brown throughout, with narrow lines of rich chestnut brown on all carinae and thoracic sutures; similar in male and female except that the dorsum of abdominal segments 2 to 6 are fawn color. Legs lost in the male, in the female wholly pale yellow. Wings hyaline with a more or less yellowish tint at the front, darker between veins Sc and R, this color expanding to cover the whole stigma. Cross veins at the stigma few and incomplete. Cross veins in the disc of the wing tending to form three more or less complete transverse series. The paired marginal intercalaries are rather long. Venation as shown in pl. 12, fig. 155.

Two males and one female from El Campamiento, Junin, Peru, June 28, 1920, collected by Dr. J. C. Bradley.

Holotype, male, C. U. No. 648, wings and genitalia mounted on slides.

This species is nearest *B. inops* but differs in shape of hind wing and in not being reticulate at the stigma of the fore wing.

## Nymphs

Neotropical nymphs of this genus differ among themselves about as do the species of the Holarctic realm. Since none of ours from South America was reared, and but one was specifically identified by supposition, it will not be profitable to describe all the forms collected, for a number of them are very much alike. Three species, showing marked differences in the length of the middle tail, are selected for description. These may be separated as follows:—

Middle tail as long as the laterals.................. *Baetis nymph* No. 1
Middle tail 5/7 as long as the laterals.................. *Baetis peruvianus* ?
Middle tail 2/5 as long as the laterals................ *Baetis nymph* No. 2

### Baetis Peruvianus Nymph (Supposition)

The supposition that this nymph belongs to the above named species is based on size, locality, and a comparison of the venation of the nymphal wing with Ulmer's figure of the venation of the hind wing of *B. peruvianus,* as given in Arch. f. Naturg. 85:53, 1919. On pl. 13, fig. 182, is shown the venation of the nymphal wing.

Length of body 7 mm., tails 7 mm. (middle one 5 mm.), additional.

Color greenish brown with a very narrow mid-dorsal pale line on head and thorax, brownish lengthwise streaks on the sides of the prothorax, two brown submedian lines on the mesothorax, these wider in front and tapering to a point behind. Knees and apical margins of abdominal segments narrowly brown as usual in this genus, and pair of brown submedian dots on each abdominal segment above. Middle leg as shown in pl. 13, fig. 179.

Tails white, as are also the very scanty fringes of soft, short hairs between them. The gills (pl. 13, fig. 167) are broad, oval, a little one-sided, obtuse at tip, and largest on middle segments.

The maxillary palpi are very weak and slender, not surpassing in length the tips of the lacinae. Mouth parts as shown in pl. 13, figs. 173, 174 and 180.

Five specimens from Puenta del Inca, Mendoza, Argentina, March 22, 1920, 9,000 to 10,000 feet altitude.

Several smaller specimens, apparently of the same species, are from Matucana, Province of Lima, Peru, May 26-28, 1920. All were collected by Dr. J. C. Bradley.

### Baetis sp. ? Nymph No. 1

Length of body 8 mm.

A nymph somewhat similar to *B. peruvianus* but larger. It shows in the venation of the hind wing a similar fork. Some specimens show a pale, open U-mark on the mesothorax opening forward with a narrow, median line crossing it, and another obscurer U-mark outside of and surrounding the first one. There

is also a broad brownish cloud crossing and covering the middle half of the fringes of the tails. Tails about equal in length.

Numerous specimens from Tambo Eneñas on the Camino del Pichis, Junin, Peru, July 4, 1920, collected by Dr. J. C. Bradley.

### Baetis sp. ? Nymph No. 2

Length of body 8 mm., tails 5 (middle one 2) mm.

Pale greenish or blackish brown with narrow darker lines across the apices of the abdominal segments and across their corners at the bases of the gills and along the margins of the legs. Dorsum of thorax with numerous obscure paler streakings. On each of the middle abdominal segments are four pale dots in two pairs, one pair close together at the base and the other pair submedian. There are short spinules upon the dorsal crest of the femora.

Gills oblique, oval, with a few of the coarsely branched tracheae tinged with purple; a chitinized rib stiffens the front border of each, and there is a small emargination at the tip of the rib in some of the middle gills.

Coarsely toothed claws, enlarged basal segments to the antennae, and the short middle tail mark this species as transitional to Baetodes; but this species has two pairs of wings, and gills on segments 1 to 7.

Half a dozen specimens Huacapistana on the Rio Tarma, Junin, Peru, June 1-3, 1920, collected by J. C. Bradley.

## BAETODES GEN. NOV.

This genus is based on the nymphs of two species from Brazil, having no hind wings and a venation that is shown in part in pl. 13, fig. 168. The nymphs are stiff, long-legged, bare tailed concolorous forms, having drooping, simple, oval gills upon segments 1 to 5 only of the abdomen, having stout, rather few-jointed antennae, and greatly reduced palpi and glossae. The middle tail is rudimentary. The dorsal crest of the femora bears a single line of long brown spines. The two nymphs are described below, the named one being the type of the genus:

### Baetodes Serratus sp. n.

Length of body of nymph 7 to 8 mm., tails 10 mm., additional; the middle one only 1 mm.

A plain, greenish brown nymph with white obovate drooping gills upon the first five abdominal segments, mid-dorsal hooks the entire length of the abdomen, long, stiff legs and a very short middle tail between the two long flexuous bare ones. Coloration nearly uniform, lighter on the sutures and underneath the body. Tails, antennae and legs grow darker toward the tips and the femora are darker

about the margins and at the ends. The legs are long, front legs slightly longest. Each of the femora bears a row of 6 to 8 stiff spines scattered along its dorsal crest. The tibiae show the white sutures indicated in figure 169 of plate 13. The claws (pl. 13, fig. 170) are stout and hooked and bear a row of rather stout teeth beneath.

The abdomen is subcylindric, regularly but slowly tapering to rear and bears a row of triangular dorsal hooks (pl. 13, fig. 178) its entire length, highest on the middle segments, diminishing both ways, and increasingly inclined backward on the hinder segments; no lateral spines. Gills on segments 1 to 5 white, ovate, obtuse, drooping obliquely downward and backward and diminishing in size to the rear. Tails bare, long, flexuous, pale at base becoming darker toward the slender tips.

The mouth parts (pl. 13, figs. 175 and 176) are characterized by the extreme weakness of both maxillary and labial palpi, and by the reduced glossae of the labium. The antennae are rather coarsely segmented, the two basal segments swollen, the first oblique; only one suture at base of flagellum is indistinct; length of antennae about half that of the thorax. The labrum is pale distinctly bordered with brown and a diffuse brownish spot occupies the V-shaped frontal suture, that in this form is well down on the face.

A number of nymphs of various sizes from Tijuca, Rio de Janeiro, Brazil, October 17, 1919.

Holotype nymph, C. U. No. 649-1, mounted on a slide.

### Baetodes Nymph No. 1

This nymph is similar in most respects, but lacks the dorsal hooks of the abdomen, has its middle tail even shorter (1/3 mm.), has the spines on the dorsal crest of femora more numerous (about 10-12) and more hair-like, and has the labrum less extensively edged with brown. It is also slightly larger (length of body 10 mm.). The legs are slightly shorter and the antennae are slightly longer than in the preceding species.

Many nymphs in alcohol from Tijuca, Rio de Janero, Brazil, collected by Dr. J. C. Bradley, October 17, 1919.

## PSEUDOCLOEON

To the tnree described neotropical species of this dipterous genus of small mayflies we add two new ones, and a description of the nymph of one undetermined species. The adults may be separated as follows:

### Key to the Species—Imagos

1—Upper division of the eye of the male turbinate or shaped like the cap of a mushroom, as high as the head.................................... 2

—Upper division of the eye of the male cylindric, erect and parallel with its fellow, twice as high as the head........................*binocularis*

2—Minute species (wing 2.25 mm.).............................*turbinops*

—Larger species (wing 4 or more mm.)................................ 3

3—Legs grayish ..........................................*oldendorffi*

—Legs brownish ................................................ 4

4—Antepenultimate joint of the ♂ forceps twice as long as wide....*dubium*

—Antepenultimate joint of the ♂ forceps twice as long as wide..*brunneum*

### Pseudocloeon Oldendorffi

Numerous adults of this little know species were collected at Santa Fe, Argentina, February 19, 1920. From a good male specimen a new figure of the forceps has been drawn, and it is presented herewith in pl. 12, fig. 161.

### Pseudocloeon Binocularis sp. n.

Male—Length of body 5 mm., of wing 4.5 mm., of tails about 9 mm.

Color rich reddish brown, nearly uniform; middle segments of the abdomen translucent whitish. Ocelli, sides and top of the upper division of the eye and flagellum of the antennae yellow. Unfortunately the end of the abdomen is lost; but a broken off bit of the tail shows pale brown annulations of the basal portion.

The very remarkable eyes of the male of this species are shown in pl. 12, fig. 156. They are quite distinctive. The venation of the wing is shown in pl. 12, fig. 149.

One male, Campamiento, Junin, Peru, July 1, 1920.

Holotype, C. U. No. 650, wings mounted on a slide, the remainder in alcohol. Also, one female in bad condition from La Chorrera, Loreto, Peru, appears to be the same species.

### Pseudocleon Turbinops sp. n.

Length of body, male and female, 3-3.5 mm., of wing 2.25 mm.

General color pale brown, darkest on the rear of the thorax, with narrow lines on the carinae of the same. Ocelli and lower part of eyes black. Upper part in the male red, translucent. Wings hyaline. Venation as shown in pl. 12 for the male in fig. 151, and for the female in fig. 150. Legs pale the fore femur with an indistinct spot at two-thirds its length. The second segment of the

fore tarsus is about half as long as the tibia and the segments diminish in length in the following order; 2, 3, 4, 5, 1.

Abdomen brown above, pale on the joinings of the segments, so that the dorsum is covered by a band of brownish quadrangles, with darker interrupted lines on the lateral margins. The female is similar to the male, with more of a yellowish tint to the thorax, and a plumbeous tint on the abdomen. Forceps of the male as shown in pl. 12, fig. 160.

Three specimens, two males and one female, Kartabo, British Guiana, October 20-22, 1920, collected at light by Mr. A. E. Emerson.

Holotype, male, C. U. No. 651, mounted on a slide.

### The Nymph

Nymphs of Pseudocloeon, determinable by lack of hind wings and by the venation discoverable in the fore wings of some of them, were taken by Dr. Bradley in both Argentina and Peru in considerable numbers. They are among the most beautifully colored of all mayfly nymphs dappled with green and brown, and are clean, agile, sprightly forms with long straightish slender claws. The mouth parts are as shown in plate 13; also the legs and the lateral margin of the abdomen. There are gills on segments 1 to 7 of the abdomen, slightly diminishing in size to rearward, erect, double on the first 6 segments, oblique ovoid-triangular in form with the anterior lamina hardly larger than the posterior, but a little thicker and more heavily pigmented along its few coarse widely branching dendritic tracheae. Legs slender, tibiae and tarsus of about equal length, consolidated into an apparently single segment with only an oblique suture across the middle of it marking their limits.

### Pseudocloeon Nymph No. 1

Length of body 7 to 9 mm., of tails 3 to 4 mm., additional, antennae 1.5 mm.

Color greenish brown marmorate with irregular longitudinal pale streaks that mostly run lengthwise on the top of the thorax, becoming darker and broader and fewer at the rear. Abdomen above with a brownish median more or less interrupted band on segments 2 to 7 divided at each side by a narrow pale line made of short curves placed end to end. Sides pale with a brown blotch upon the middle of the flattened-out lateral margin; a brown mark across the apex of segment 10. Lateral spines on abdominal segments as shown in pl. 13, fig. 177. Mouth parts as shown in the same plate, figs. 164, 165, 171 and 172.

The tails bear closely appressed whorls of short spinules, and fringes of pale hairs within, and there is a band of darker color crossing the three tails at three-fourths their length. The middle tail is very little shorter than the laterals.

Numerous specimens from Cosquin, Argentina, March 8, 1920, and from El Campamiento, Junin, Peru, June 19, 1920, collected by Dr. J. C. Bradley.

# EXPLANATION OF PLATES

Unless otherwise stated, the drawings were made with the aid of the camera lucida.

## PLATE I

Venation of Campsurus and Tortopus.

Abbreviations for venation given under explanation of fig. 5.

Fig. 1. Fore wing, *Campsurus evanidus.*
Fig. 1A. Hind wing of same.
Fig. 1B. Portion of fore wing of same, for variant venation.
Fig. 2. Fore wing, *Campsurus scutellaris.*
Fig. 2A. Hind wing of same.
Fig. 3. Fore wing, *Campsurus pallidus.*
Fig. 3A. Hind wing of same.
Fig. 4. Fore wing, *Campsurus lucidus.*
Fig. 4A. Hind wing of same.
Fig. 5. Fore wing, *Campsurus major;* b, bulla; C, costa; Cu, cubitus; h, humeral cross vein; Int, intercalaries; M, media; R, radius; Sc, subcosta; st, stigma.
Fig. 5A. Hind wing of same.
Fig. 6. Fore wing, *Campsurus segnis.*
Fig. 6A. Hind wing of same.
Fig. 7. Fore wing, *Campsurus corumbanus.*
Fig. 7A. Hind wing of same.
Fig. 7B. Portion fore wing of same, for variant venation.
Fig. 8. Fore wing, *Campsurus violaceous.*
Fig. 8A. Hind wing of same.
Fig. 9. Fore wing, *Tortopus igaranus.*
Fig. 9A. Hind wing of same.
Fig. 9B. Portion of fore wing of same, for variant venation.
Fig. 9C. Portion of fore wing of same, for variant venation.

## PLATE II

Venation of Campsurus, Campylocia and Hexagenia

Fig. 10. Fore wing, *Campsurus mutilus.*
Fig. 10A. Hind wing of same.
Fig. 11. Fore wing, *Campsurus Holmbergi?*
Fig. 11A. Hind wing of same.
Fig. 12. Fore wing, *Campylocia ampla.*

Fig. 12A. Hind wing of same.
Fig. 13. Fore wing, *Campsurus striatus.*
Fig. 13A. Hind wing of same.
Fig. 14. Fore wing, *Campsurus notatus.*
Fig. 14A. Hind wing of same.
Fig. 15. Fore wing, *Campsurus claudus.*
Fig. 15A. Hind wing of same.
Fig. 16. Fore wing, *Hexegenia albivitta Walker.*
Fig. 16A. Hind wing of same.

## PLATE III

*Campsurus, Tortopus, Campylocia*

Fig. 17. Genitalia, ♂ *Campsurus segnis.*
Fig. 18. Genitalia, ♂ *Campsurus scutellaris.*
Fig. 19. Egg and egg cap, *Campsurus corumbanus.*
Fig. 20. Second leg, ♂ *Campsurus segnis.*
Fig. 21. Extruded ovary and oviduct, *Campylocia ampla.* Oviduct, N, nematode porasite.
Fig. 22. Gill vestige, imago of *Campylocia ampla.* Tr, main lateral trunk; G, gill; N, nematode porasite.
Fig. 23. Genitalia ♂ *Hexagenia albivitta* Walker.
Fig. 24. Genitalia ♂ *Campsurus violaceus.*
Fig. 25. Genitalia ♂ *Campsurus notatus.*
Fig. 26. Genitalia ♂ *Campsurus pallidus.*
Fig. 27. Reproductive system, ♀ *Campsurus corumbanus.* Ov, ovary; Sr, seminal receptacle; Ut, uterlus; Ovi, oviduct.
Fig. 28. Genitalia ♂ *Campsurus major.*
Fig. 29. Genitalia ♂ *Campsurus evanidus.*
Fig. 30. Genitalia ♂ *Campsurus lucidus.*
Fig. 31. Egg, *Campylocia ampla.*
Fig. 32. Legs ♀ *Tortopus igaranus;* 32A, 32B, 32C, first, second and third legs, respectively.
Fig. 33. Genitalia, ♂ *Campylocia anceps.*

## PLATE IV

*Campsurus nymph*

Fig. 34. Left mandible, dorsal aspect.
Fig. 35. Third leg.
Fig. 36. Labrum.
Fig. 37. Hypopharynx.

Fig. 38. First leg.
Fig. 39. Nymph, Campsurus sp?
Fig. 40. Labium.
Fig. 41. Right mandible, ventral aspect.
Fig. 42. Second leg.
Fig. 43. First gill.
Fig. 44. Maxilla.
Fig. 45. Fourth gill.

## PLATE V

(?) *Metamonius nymph*

Fig. 46. Head, lateral aspect.
Fig. 47. First leg.
Fig. 48. Second leg.
Fig. 49. Third leg.
Fig. 50. Tail segments, in detail.
Fig. 51. Fore wing showing incipient venation.
Fig. 52. Head, dorsal aspect.
Fig. 53. Thorax, ventral aspect, showing position of gills.
Fig. 54. Abdomen and tails, dorsal aspect.
Fig. 55. Maxilla.
Fig. 56. Right mandible.
Fig. 57. Tarsal claw, first leg.
Fig. 58. Tarsal claw, second leg.
Fig. 59. Tarsal claw, third leg.
Fig. 60. Labium.

## PLATE VI

*Lachlania nymph*

Fig. 61. Antennal segment in detail.
Fig. 62. First leg.
Fig. 63. Second leg.
Fig. 64. Tarsal claw, first leg.
Fig. 65. Tarsal claw, second leg.
Fig. 66. Tarsal claw, third leg.
Fig. 67. Third leg.
Fig. 68. Fore wing, showing incipient venation.
Fig. 69. Front border, head.
Fig. 70. Metathorax, first and second abdominal segments; G, ventral abdominal gill.

Fig. 71. Abdomen and tails, dorsal aspect.
Fig. 72. Labium.
Fig. 73. Labrum.
Fig. 74. Left mandible.
Fig. 75. Maxilla bearing basal gill-tuft.
Fig. 76. Egg, *Oligoneuria anomala.*

## PLATE VII

*Leptohyphes, imago and nymph*

Fig. 77. Fore wing, *Leptohyphes indicator.*
Fig. 77A. Hind wing of same.
Fig. 78. Male genitalia of same.
Fig. 79. First gill of nymph *Leptohyphes* sp ? No. 2.
Fig. 80. Third gill of same.
Fig. 81. Fifth gill of same.
Fig. 82. Antero-lateral angle of prothorax of same.
Fig. 83. Abdomen of nymph of same.
Fig. 84. Wing of nymph of *Leptohyphes* sp ? No. 1, showing incipient venation.
Fig. 85. Head, anterior aspect, nymph of *Leptohyphes* sp ? No. 2.
Fig. 86. Labium of nymph of same.
Fig. 87. Labrum of nymph of *Leptohyphes* sp ? No. 1.
Fig. 88. Nymph of *Leptohyphes* sp ? No. 1.
Fig. 89. Fore wing, *Leptohyphes mollipes.*
Fig. 89A. Hind wing of same.
Fig. 90. Male forceps and penis of *Leptohyphes mollipes,* one side only.
Fig. 91. Left mandible nymph, *Leptohyphes* sp ? No. 2.
Fig. 92. First leg of same.
Fig. 93. Second leg of same.
Fig. 94. Maxilla of same.
Fig. 95. Third leg of same.

## PLATE VIII

*Atalophlebia, Atalonella and Thraulodes*

Fig. 96. Fore wing, *Atalophlebia fulvipes.*
Fig. 96A. Hind wing of same, more enlarged.
Fig. 97. Fore wing, *Atalonella ophis.*
Fig. 97A. Hind wing of same.
Fig. 98. Male genitalia of *Atalophlebia fulvipes.*
Fig. 99. Fore wing, *Thraulodes telegraphicus.*
Fig. 99A. Hind wing of same, more enlarged.

Fig. 100. Fore wing, *Thraulodes plicatus.*
Fig. 100A. Hind wing of same.
Fig. 101. Male genitalia of *Atalonella ophis,* ventral aspect.
Fig. 101A. Same lateral aspect.
Fig. 102. Male genitalia of *Thraulodes telegraphicus.*

## PLATE IX

Siphlonella, Atalophlebia, Atalonella, ? Nousia, ? Deleatidium, and Thraulodes nymphs

Fig. 103. Maxilla, *Siphlonella ventilans.*
Fig. 104. Third leg of same.
Fig. 105. Maxilla, *Atalophlebia sp* ?
Fig. 106. Left mandible, *Atalonella ophis.*
Fig. 107. Tarsal claw, first leg of same.
Fig. 108. First leg of same.
Fig. 109. Labium, *Siphlonella ventilans.*
Fig. 110. Head and labrum, *Atalophlebia sp* ?
Fig. 111. Labium of same.
Fig. 112. Labrum, *Atalonella ophis.*
Fig. 113. Hind wing of same, showing incipient venation.
Fig. 114. Lateral spines on abdominal segments 2 to 9 of *Atalonella ophis.*
Fig. 115. Lateral spines ? *Deleatidium sp* ? nymph No. 2.
Fig. 116. Labrum, *Siphlonella ventilans.*
Fig. 117. Left mandible of same.
Fig. 118. Second leg, *Atalophlebia sp* ?
Fig. 119. Tarsal claw, second leg of same.
Fig. 120. Lateral spines on abdominal segments 8 and 9 of ? *Nousia sp* ?
Fig. 121. Left mandible, *Atalophlebia sp* ?
Fig. 122. Fourth gill of same.
Fig. 123. Lateral spine of *Thraulodes sp* ?, showing eroded outer margin.

## PLATE X

*Hermanella thelma nymph*

Fig. 124. Spines on posterior border of rear abdominal segments.
Fig. 125. Hypopharynx.
Fig. 126. Fifth gill.
Fig. 127. Second gill.
Fig. 128. Seventh gill.
Fig. 129. ? Hermanella sp., maxilla swung outward, showing plancton-gathering brushes.

Fig. 130. *Hermanella thelma,* dorsal view of whole nymph.
Fig. 131. Labrum.
Fig. 132. Labium.
Fig. 133. Fore wing, *Hermanella thelma,* showing incipient venation.
Fig. 133A. Hind wing of same.
Fig. 134. Left mandible.
Fig. 135. Third leg.
Fig. 136. Maxilla.

## PLATE XI

*Thraulus, Choroterpes.*

Fig. 137. Fore wing, *Thraulus bradleyi.*
Fig. 137A. Hind wing of same.
Fig. 138. Fore wing, *Thraulus maculatus.*
Fig. 138A. Hind wing of same.
Fig. 139. Fore wing, *Thraulus missionensis* ?
Fig. 139A. Hind wing of same.
Fig. 140. Fore wing, *Choroterpes bilineata.*
Fig. 140A. Hind wing of same.
Fig. 141. Fore wing, *Choroterpes emersoni.*
Fig. 141A. Hind wing of same.
Fig. 142. Male genitalia, *Thraulus bradleyi.*
Fig. 143. Male genitalia, *Thraulus maculatus.*
Fig. 144. Male genitalia, *Thraulus missionensis* ?
Fig. 145. Male genitalia, *Choroterpes emersoni.*
Fig. 146. End of abdomen of female of *Choroterpes emersoni,* showing ovipositor.

## PLATE XII

Fig. 147. Fore wing, *Callibaetis pollens.*
Fig. 147A. Hind wing of same.
Fig. 148. Fore wing, *Baetis melleus.*
Fig. 148A. Hind wing of same.
Fig. 149. Wing *Pseudocloeon binocularis.*
Fig. 150. Wing *Pseudocloeon turbinops,* female.
Fig. 151. Wing *Pseudocloeon turbinops,* male.
Fig. 152. Fore wing, *Callibaetis viviparus.*
Fig. 152A. Hind wing of same, more enlarged.
Fig. 153. Fore wing, *Baetis socius.*
Fig. 153A. Hind wing of same, more enlarged.

Fig. 154. Embryo in egg of *Callibaetis viviparus,* taken from body of female.
Fig. 155. Fore wing, *Baetis dryops.*
Fig. 155A. Hind wing of same.
Fig. 156. Head, *Pseudocloeon binocularis,* from the front.
Fig. 157. Fore wing, *Baetis tantillus.*
Fig. 157A. Hind wing of same, more enlarged.
Fig. 158. Male forceps, *Baetis melleus.*
Fig. 159. Male forceps, *Baetis dryops.*
Fig. 160. Male forceps, *Pseudocloeon turbinops.*
Fig. 161. Male forceps, *Pseudocloeon oldendorffi.*
Fig. 162. Male forceps, *Callibaetis pollens.*

## PLATE XIII

*Pseudocloeon, Baetis, Baetodes nymphs*

Fig. 163. Second leg, *Pseudocloeon sp* ?
Fig. 164. Right mandible of same.
Fig. 165. Maxilla of same.
Fig. 166. Left mandible, *Baetodes serratus.*
Fig. 167. Gill, *Baetis peruvianus.*
Fig. 168. Fore wing, *Baetodes serratus,* showing incipient venation.
Fig. 169. Second leg of same.
Fig. 170. Tarsal claw, second leg of same.
Fig. 171. Labium, *Pseudocloeon sp* ?
Fig. 172. Labrum of same.
Fig. 173. Labium, *Baetis peruvianus.*
Fig. 174. Labrum of same.
Fig. 175. Labium, *Baetodes serratus.*
Fig. 176. Labrum of same.
Fig. 177. Lateral spines on abdomen, *Pseudocloeon sp.*
Fig. 178. Dorsal hooks on abdomen, *Baetodes serratus.*
Fig. 179. Second leg, *Baetis peruvianus.*
Fig. 180. Maxilla of same.
Fig. 181. Hind wing of same, more enlarged than is the fore wing.
Fig. 182. Lacinia from right mandible of same.
Fig. 183. Left mandible of same.
Fig. 184. Maxilla, *Baetodes serratus.*
Fig. 185. Antennae of same.

PLATE I

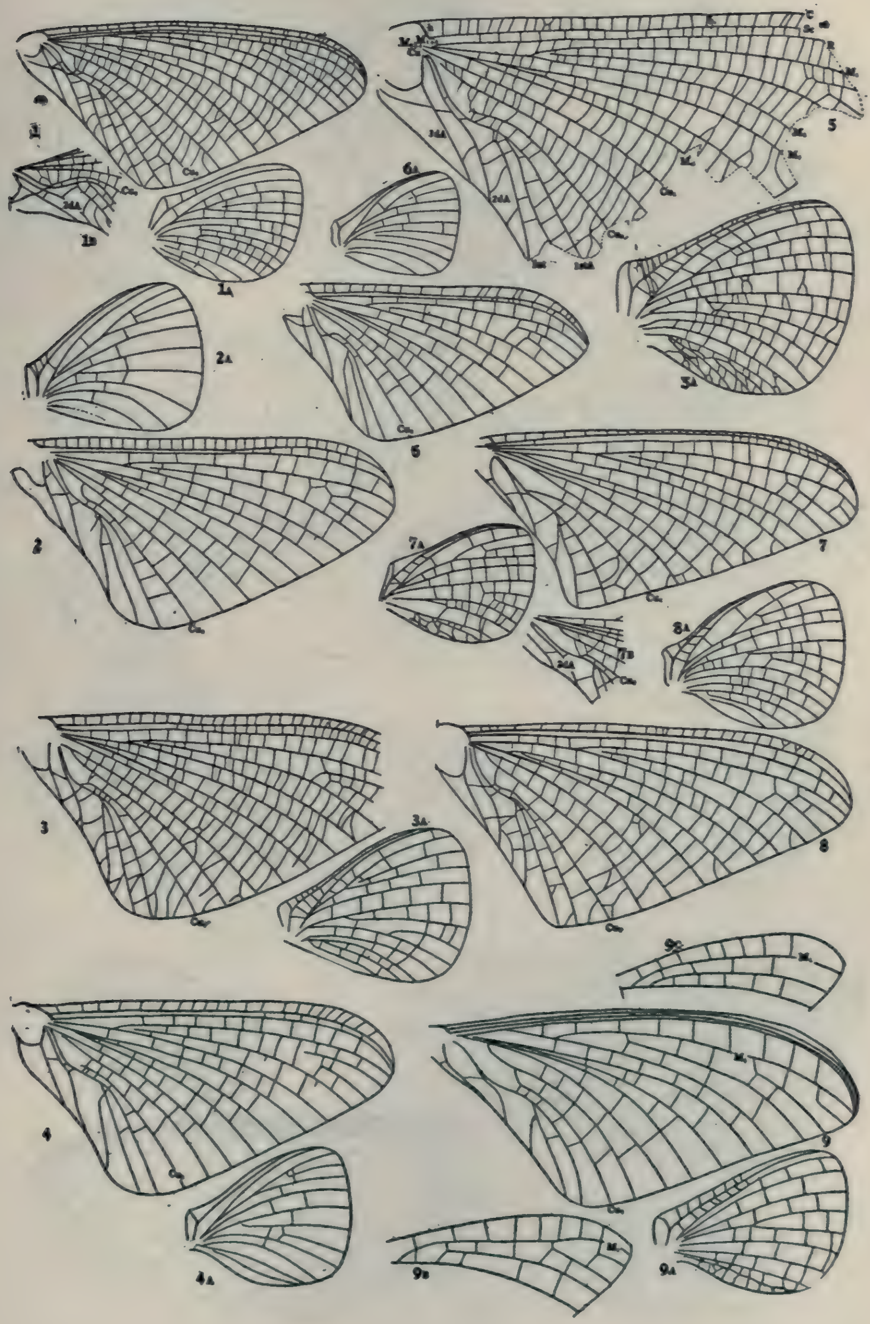


PLATE II

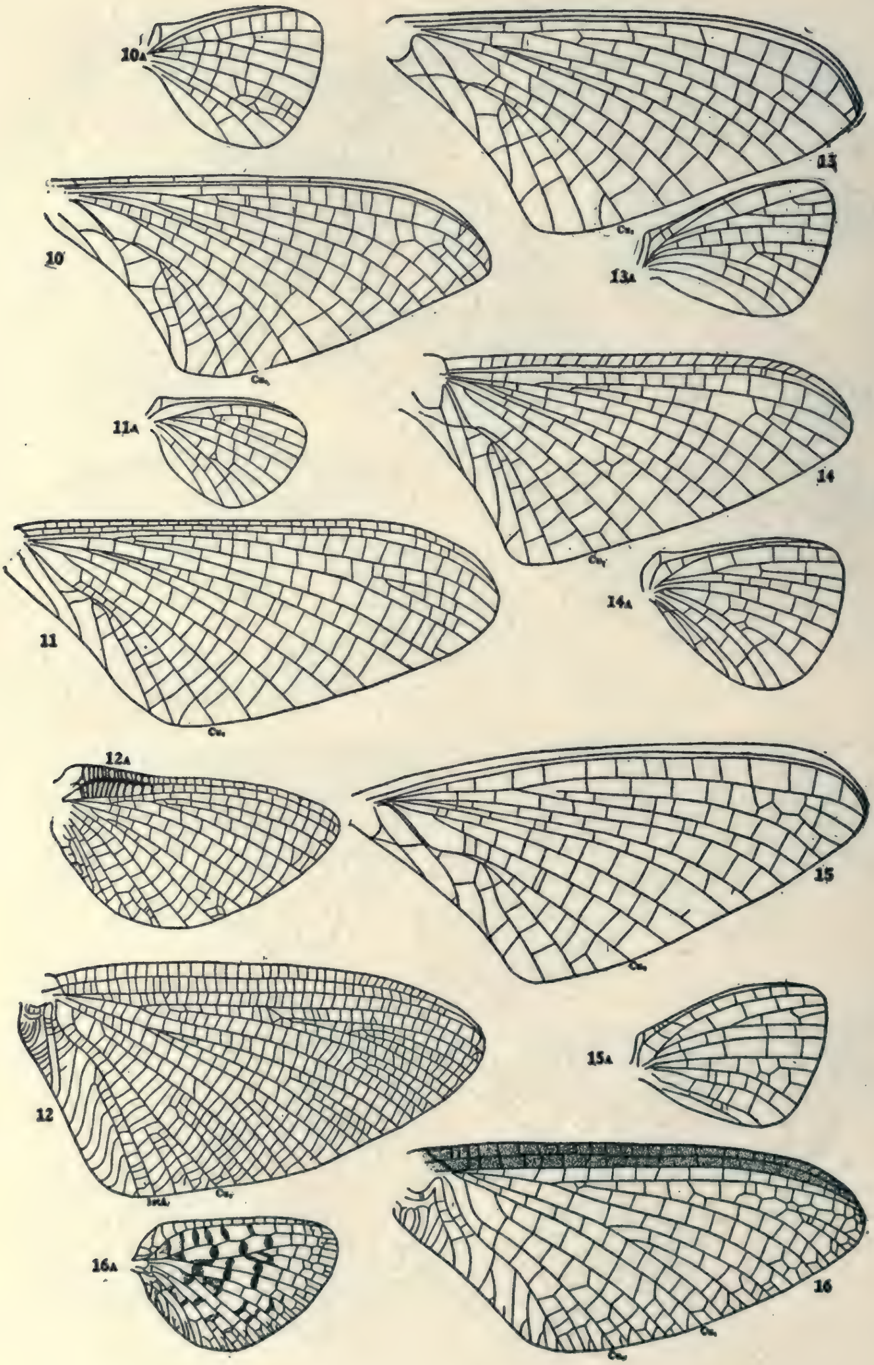


PLATE III

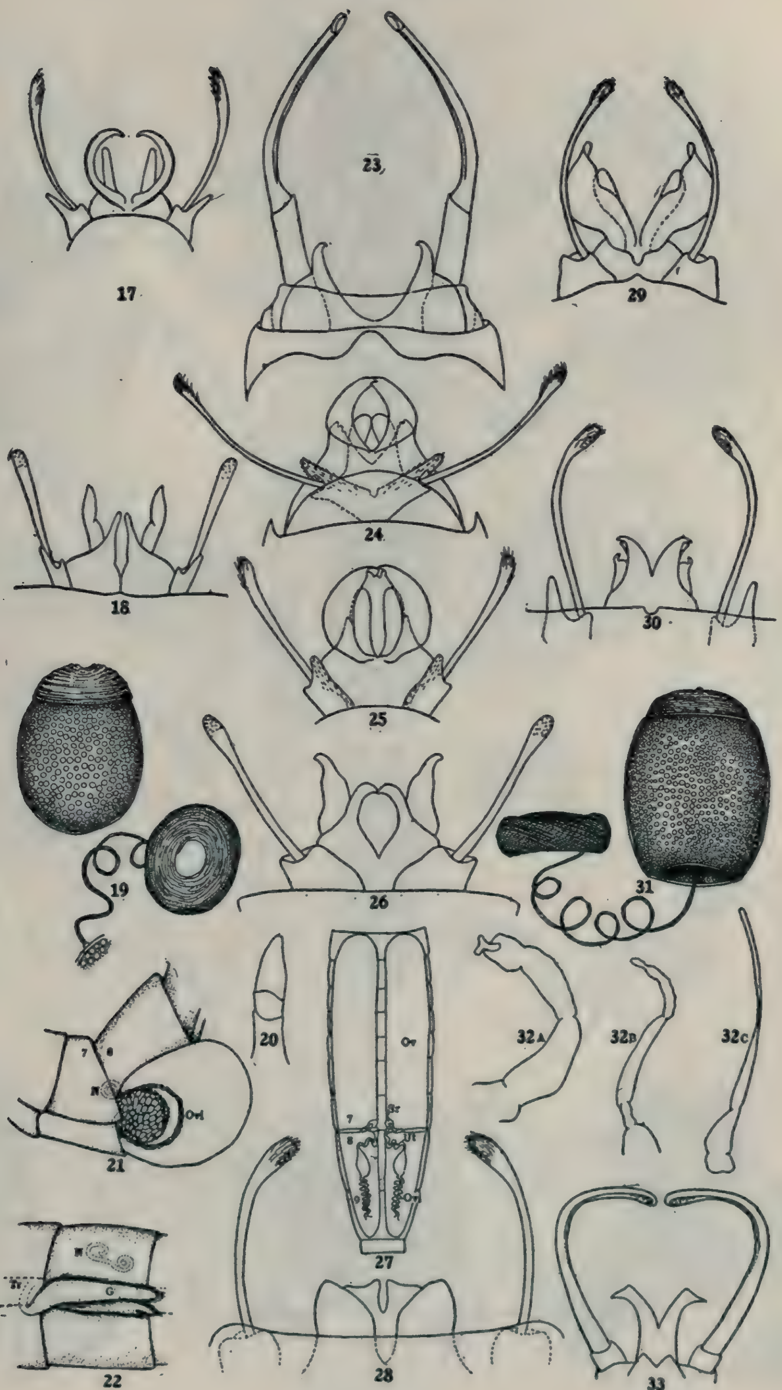

17
23
29
24
18
25
30
19
26
31
20
Ov
32A
32B
32C
7
8
N
Ov
21
St
Ov
27
N
St
G
22
28
33

PLATE IV

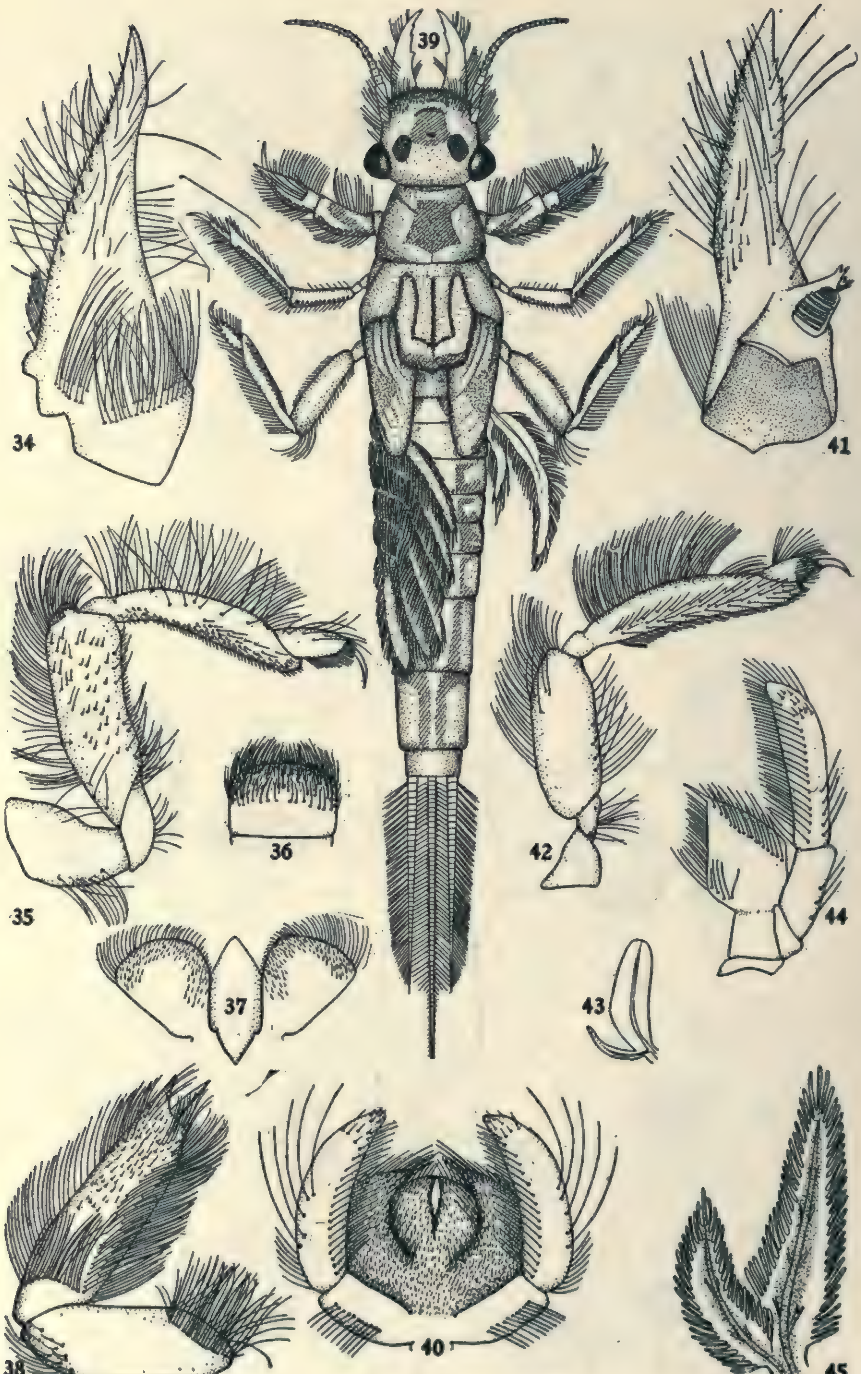


PLATE V

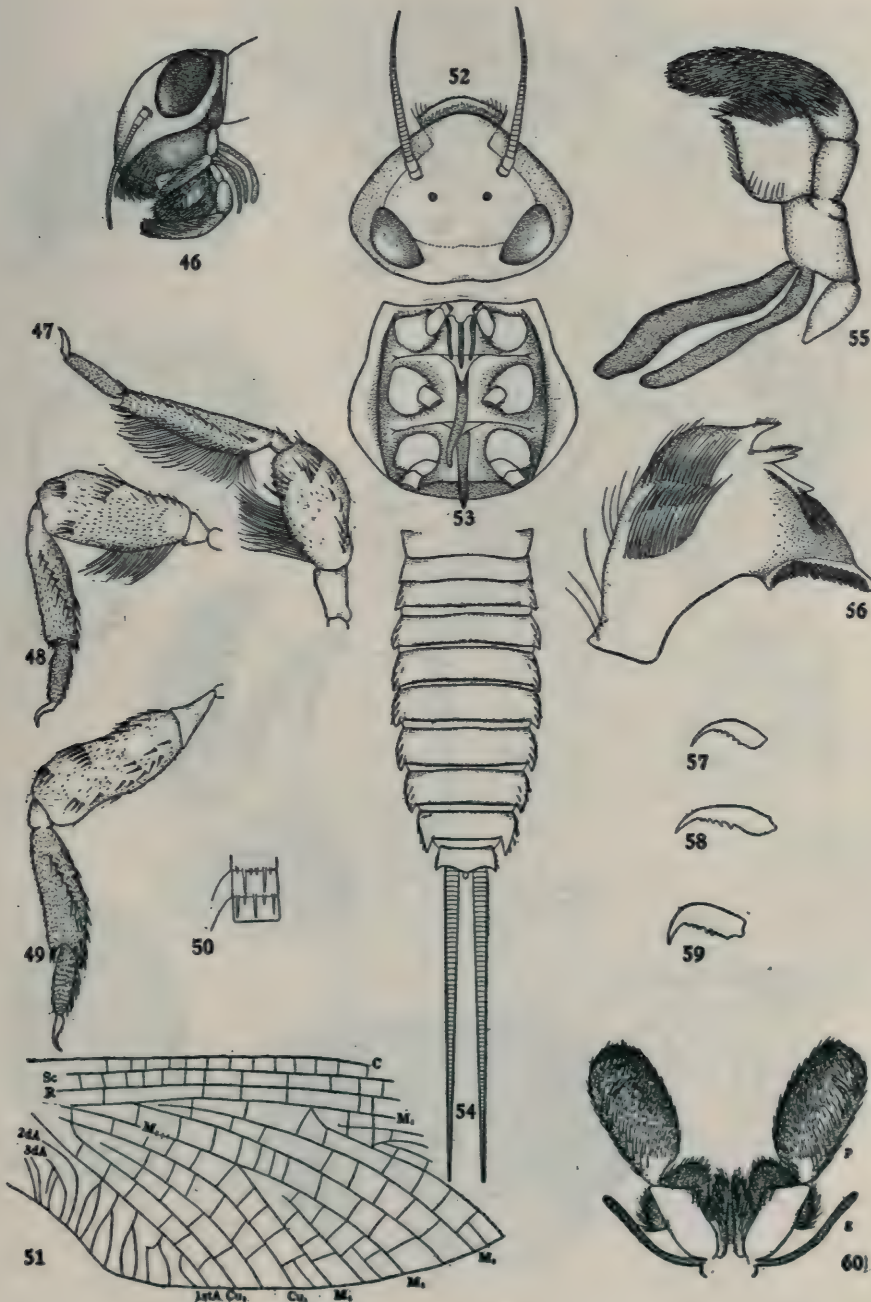


PLATE VI

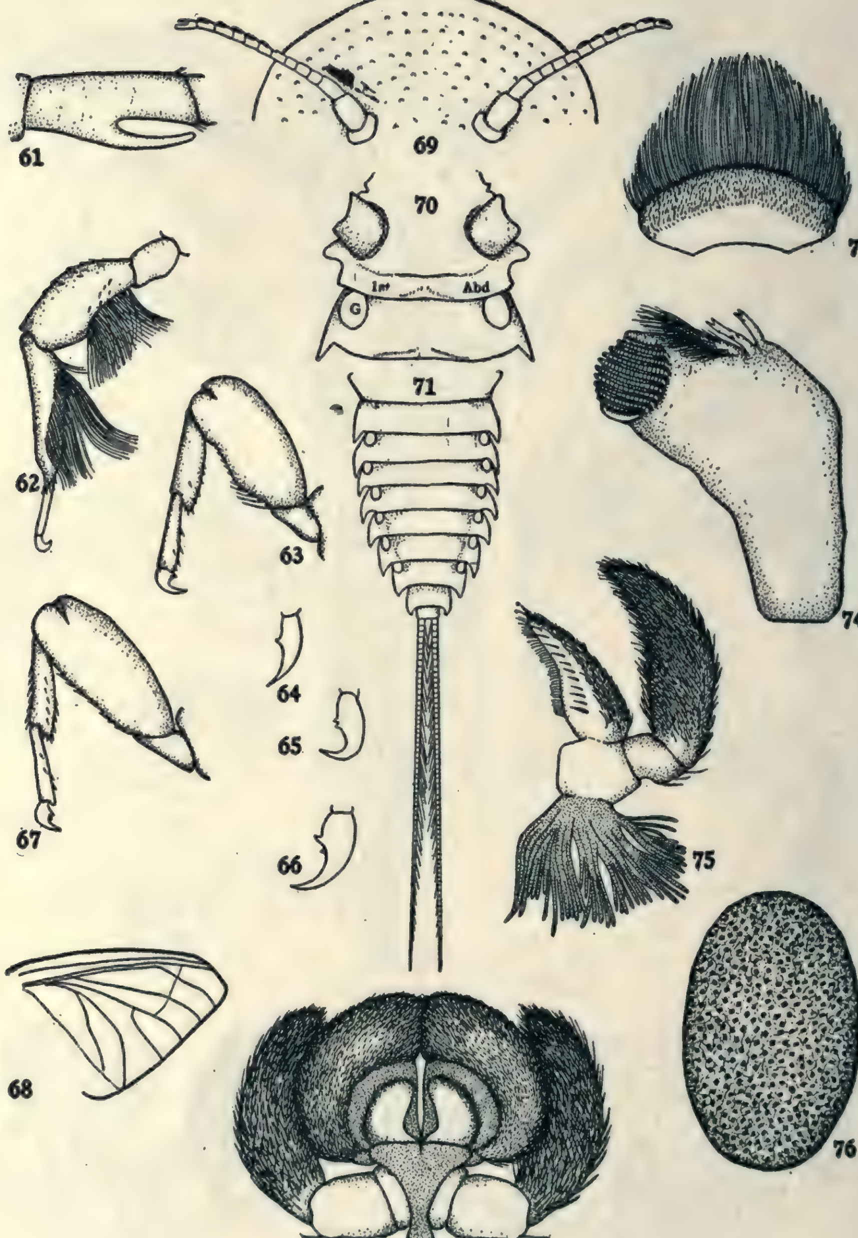
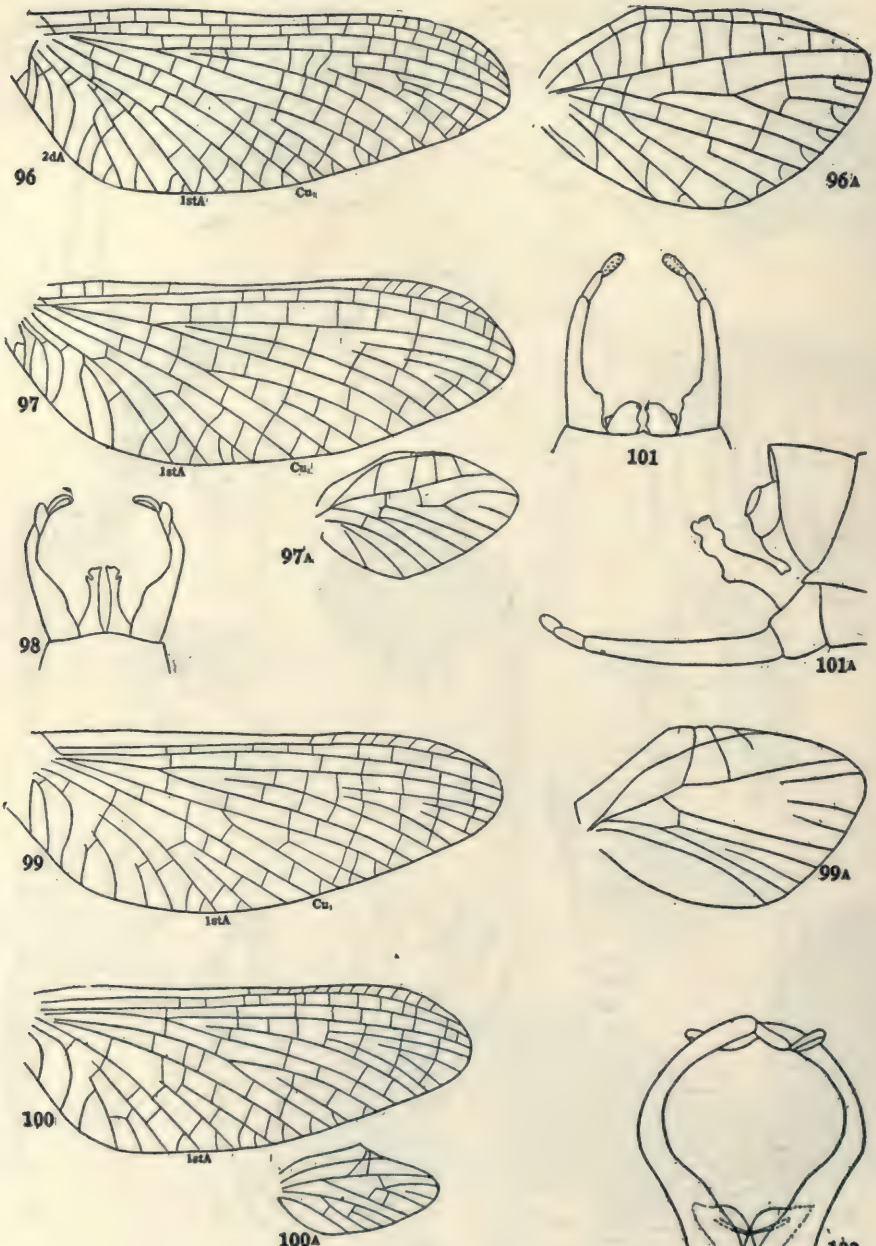
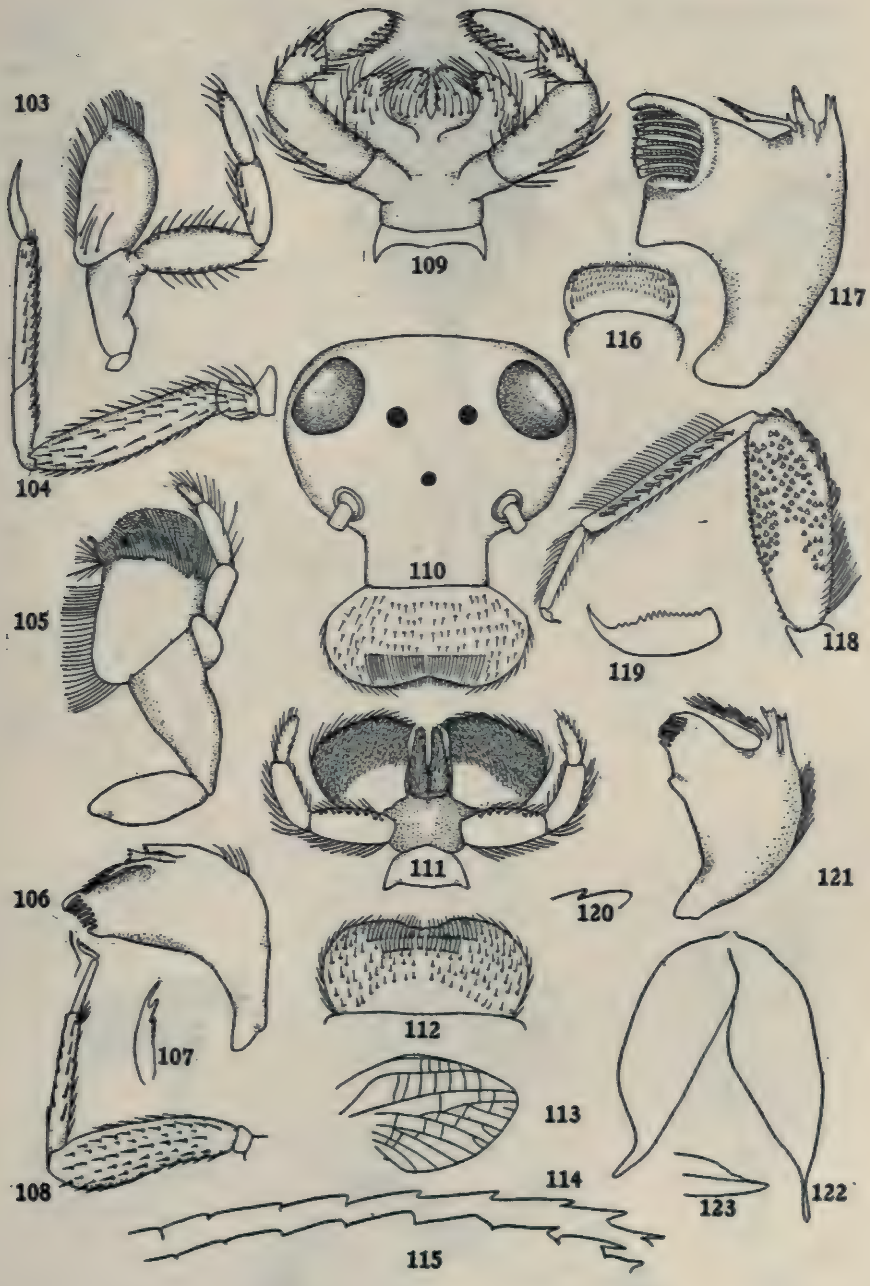


PLATE VII

PLATE VIII


96
2dA
1stA
$Cu_2$
96A
97
1stA
$Cu_2$
97A
98
101
101A
99
1stA
$Cu_1$
99A
100
1stA
100A
102


103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123

# PLATE X

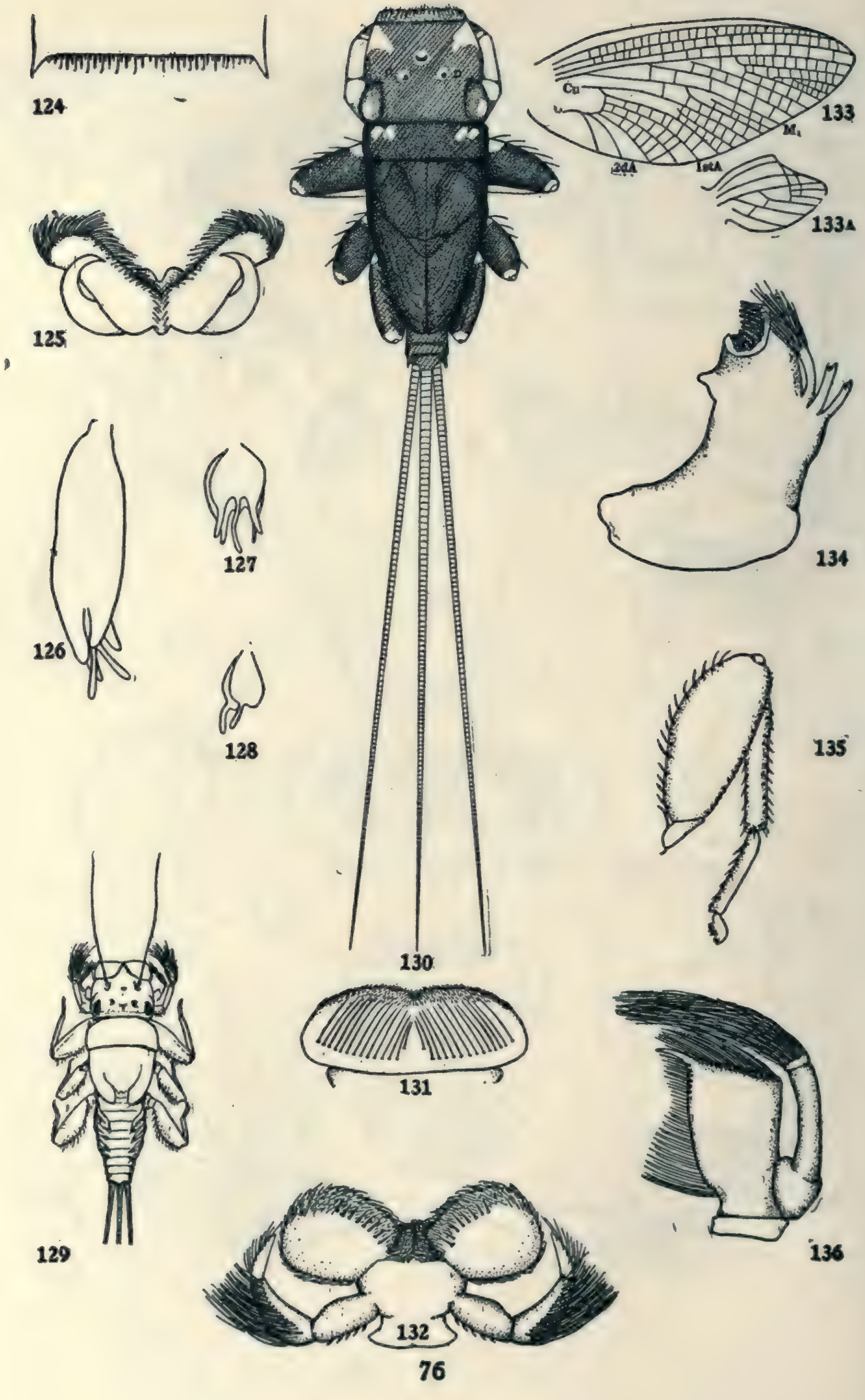
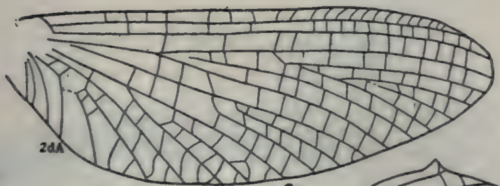

124
125
126
127
128
129
130
131
132
133
Cu
M
2dA
1stA
133A
134
135
136

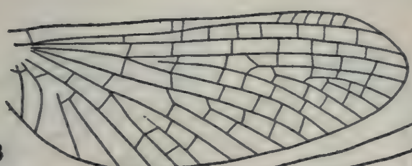
PLATE XI



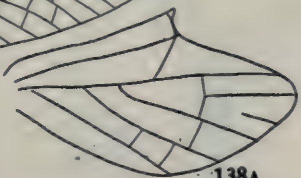

137

137A

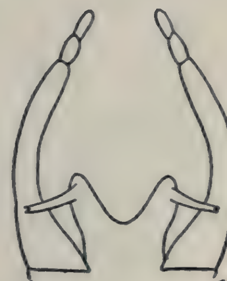
142



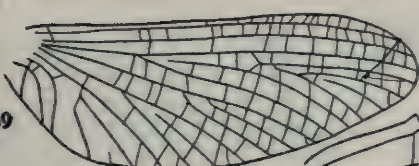
138



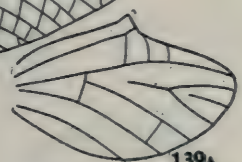
138A



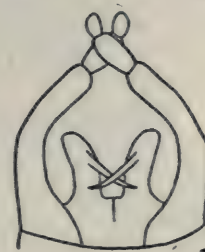
143



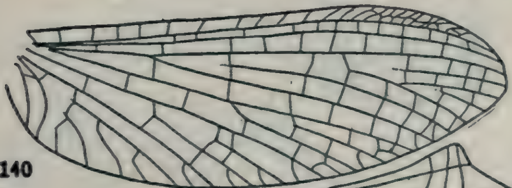
139



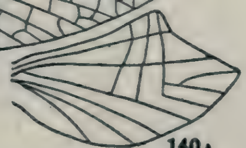
139A



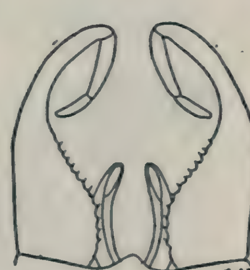
144



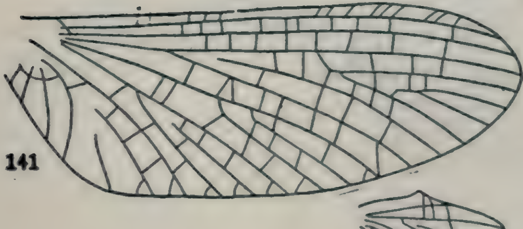
140



140A



145



141

141A

146

PLATE XII

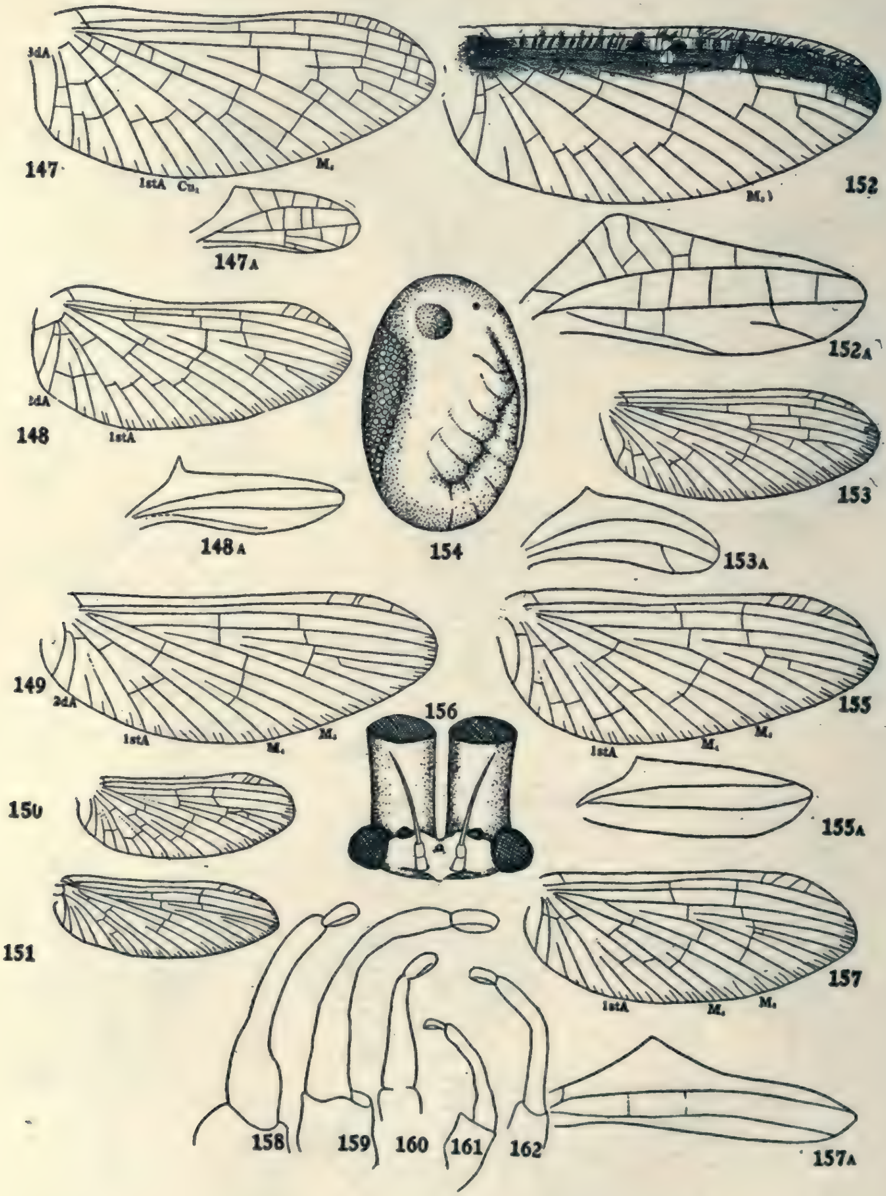
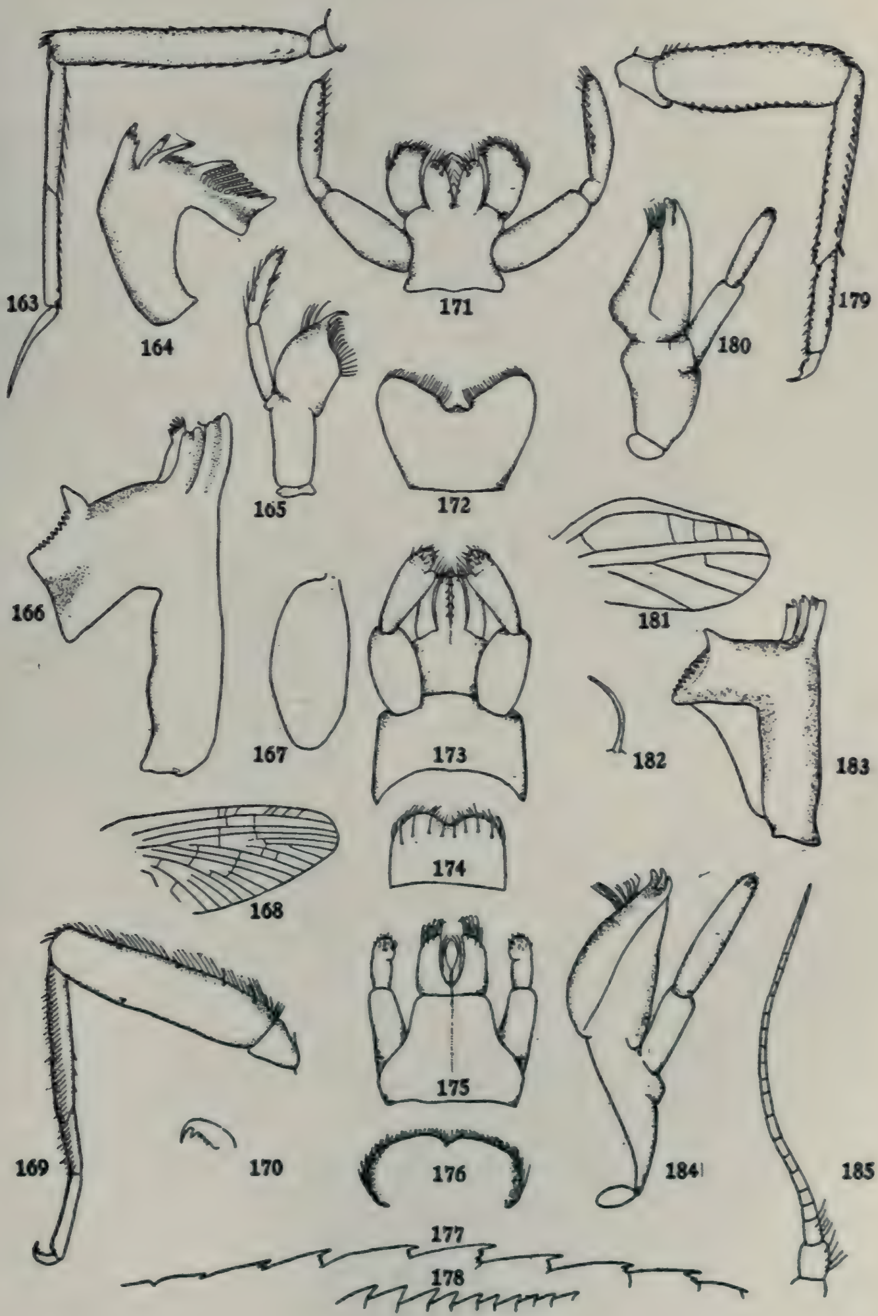

147
3dA
1stA
$Cu_2$
$M_4$
147A
148
2dA
1stA
148A
149
2dA
1stA
$M_4$
150
151
152
$M_4$
152A
153
153A
154
155
1stA
$M_4$
155A
156
157
1stA
$M_4$
157A
158
159
160
161
162

PLATE XIII


163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185

BULLETIN NO. 27 1926 ENTOMOLOGICAL SERIES NO. 5

# BULLETIN
of the
# LLOYD LIBRARY
of
# BOTANY, PHARMACY & MATERIA MEDICA

FOUNDED, ENDOWED AND MAINTAINED BY
CURTIS G. LLOYD
CINCINNATI, OHIO

ENTOMOLOGICAL SERIES NO. 5

A Preliminary Biological Survey of

# The Lloyd-Cornell Reservation

By

MEMBERS OF THE SCIENTIFIC STAFF OF
CORNELL UNIVERSITY

# Publications Issued by the Lloyd Library

(Complete List to April 1, 1924.)

## BULLETIN OF THE LLOYD LIBRARY

of

## Botany, Pharmacy and Materia Medica

No. 1. Reproduction Series No. 1, by John Uri Lloyd.
Collections for an essay towards a Materia Medica of the United States by Benjamin Smith Barton, 1798 and 1804.

No. 2. Reproduction Series No. 2, by John Uri Lloyd.
The Indian Doctor's Dispensatory, being Father Smith's advice respecting diseases and their cure, by Peter Smith, of the Miami Country, 1813.

No. 3. Mycological Series No. 1.
The Genera of Gastromycetes, by C. G. Lloyd.

No. 4. Pharmacy Series No. 1, by John Uri Lloyd.
References to Capillarity to the end of the year 1900, being Chapter VII of "A Study in Pharmacy."

No. 5. Mycological Series No. 2.
The Geastrae, by C. G. Lloyd.

No. 6. Reproduction Series No. 3, by John Uri Lloyd.
Materia Medica Americana Potissimum Regni Vegetabilis, by Johannes David Schoepf, 1787.

No. 7. Reproduction Series No. 4, by John Uri Lloyd.
An account of some of the vegetable productions naturally growing in this part of America, botanically arranged by the Rev. Manasseh Cutler.

No. 8. Mycological Series No. 3.
The Lycoperdaceae of Australia, New Zealand, and Neighboring Islands, by C. G. Lloyd.

No. 9. Reproduction Series No. 5, by John Uri Lloyd.
An investigation of the properties of the Sanguinaria Canadensis or Puccoon, by William Downey.
Travels through the interior part of North America in the years 1766, 1767, and 1768, by J. Carver.
Libellus de Usu Medico Pulsatillae Nigricantis.

No. 10. Reproduction Series No. 6, by John Uri Lloyd.
Hydrastis Canadensis.

No. 11. Reproduction Series No. 7, by John Uri Lloyd.
Life and medical discoveries of Samuel Thomson and a history of the Thomsonian Materia Medica.

No. 12. Pharmacy Series No. 2, by John Uri Lloyd.
The Eclectic Alkaloids, Resins, Resinoids, Oleo-Resins, and Concentrated Principles.

No. 13. Mycological Series No. 4.
Synopsis of the Known Phalloids, by C. G. Lloyd.

BULLETIN NO. 27 1926 ENTOMOLOGICAL SERIES NO. 5

# BULLETIN
of the
# LLOYD LIBRARY
of
## BOTANY, PHARMACY & MATERIA MEDICA

FOUNDED, ENDOWED AND MAINTAINED BY

CURTIS G. LLOYD

CINCINNATI, OHIO

ENTOMOLOGICAL SERIES NO. 5

A Preliminary Biological Survey of

# The Lloyd-Cornell Reservation

By

MEMBERS OF THE SCIENTIFIC STAFF OF
CORNELL UNIVERSITY

The investigation upon which this volume is based was in part supported by a grant from the Heckscher Foundation for the Advancement of Research, established by August Heckscher at Cornell University.

# CONTENTS

## INTRODUCTION



## FLORA AND FAUNA



## SPECIAL STUDIES ON TRICHOPTERA


FIG. I. REGIONAL MAP SHOWING THE LOCATION OF THE LLOYD-CORNELL RESERVATION

## A Preliminary Biological Survey of

# THE LLOYD-CORNELL RESERVATION

## INTRODUCTION

The wild life preserve known as the Lloyd-Cornell Reservation lies fifteen miles northeast of Ithaca, New York, and one mile east of the village of McLean in the upper Fall Creek valley. It has an elevation above the sea level of something more than 1,100 feet. It lies in the lowland adjacent to an eastern tributary of Fall Creek known as Beaver Creek or Beaver Brook, in a region of morainal deposits of great irregularity. It is an uncultivated area of bogs and ridges comprising the greater part of the Mud Pond basin. Within the basin are a number of cold upland bogs, that are of great biological interest.

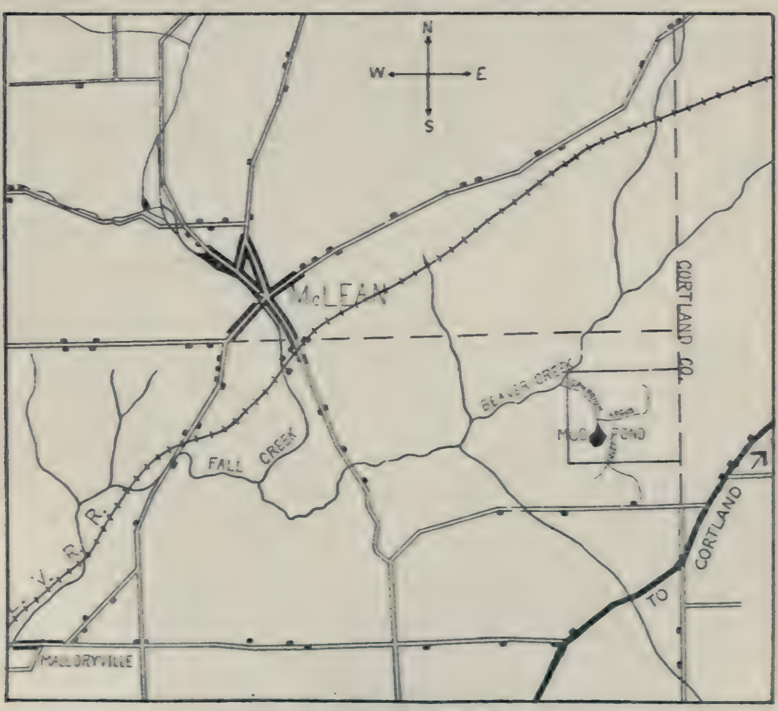



FIG. 2. MAP SHOWING LOCATION OF THE LLOYD-CORNELL RESERVATION IN RELATION TO ROADS AND STREAMS (ENLARGED FROM U. S. GEOL. SURV., TOPOGRAPHIC QUADRANGLE, WITH ALTERATIONS)

This preserve is easily accessible from the railroad station at McLean or from the nearby state highway that runs between Dryden and Cortland, New York. It is compact, so that one may see much without travelling great distances.

A survey of it was begun in the spring of 1916 by several graduate students in the Department of Entomology and Limnology in Cornell University, three of whom, J. T. Lloyd, P. W. Claassen, and R. N. Chapman, spent the Saturdays of that season in mapping with a plane table, and in collecting from the bogs. Professor A. A. Allen and Dr. C. P. Alexander also assisted in the beginning. After Dr. Lloyd in the summer of 1916 had joined the French Army, American participation in the great world war put a stop to the work. Interest revived, however, when in 1919 Mr. C. G. Lloyd of Cincinnati purchased the tract and placed it in the keeping of the trustees of the Lloyd Library to be maintained as a preserve in its natural state in perpetuity. Mr. Lloyd had the preserve enclosed with a strong wire fence to keep out grazing animals, and he provided a small fund for upkeep, and arranged for the appointment by the President of Cornell University of a local custodian. These measures insure that this spot, so interesting biologically, will be available to students of future generations.

In the spring of 1924, some twenty-four members of the scientific staff at Cornell University met together and arranged the preliminary biological survey of which this volume is the report. Aided by a grant from the Heckscher Research Foundation of Cornell University, a two-room shack was built on the reservation, a collecting outfit was assembled in it and several collectors were maintained there through the season, engaged principally in gathering the smaller animals. The work of all other collaborators has been done gratuitously, as scientific service.

As a result of these activities and aids we now have a fine bit of wild nature in the permanent keeping of a Board of Trustees, secure against commercial molestation, and available for scientific use in the future. We have made a good beginning toward a knowledge of its present flora and fauna; and when this report is published, we shall have that knowledge in available form. We have as a headquarters for work in the reservation a substantial two-room shack, that will shelter collectors and their equipment in years to come. We know, mainly by inference, a little of the past history of the Mud Pond basin, and we have established data that will in future years enable those who come after us to measure the changes that occur in it.

This report covers very briefly a few features of the environment—soils, waters, and topography of the original basin—and a first listing of the plants and animals found, together with brief ecological notes on habitats and associations. The lists are largely the result of general collecting: there has been little opportunity, as yet, for more intensive study. These lists of the larger plants and animals are probably fairly complete; but many additions will be made to those of the smaller ones. Some of the lower groups—even important ones, such as the algae among plants—have been passed almost unnoticed. Times and stages and seasons and relative abundance have been noted with some care, in the hope that future students may be helped by knowing what is there and where and when to find it.

James G. Needham
*Custodian*

# THE TOPOGRAPHIC SITUATION

The Lloyd-Cornell Reservation lies, as shown by map (page 5), in the south side of Beaver Creek valley. It is a quadrangular area of some eighty-one acres, comprising the greater part of the Mud Pond basin. This basin is an irregular depression in the lowland at the foot of pastured slopes. It is rimmed about on the north and separated from Beaver Creek by an esker-like ridge that joins with the hills to inclose it. Sphaerium Brook has cut its way through this ridge to join Beaver Creek. The ridge closely parallels Beaver Creek for the greater part of its length. Its surface is very irregular, as the contour lines on the map clearly show. Midway its length it rises steeply from the bank of the creek to a height of seventy feet above the general level, in a hump that is known as "Observation Hill." On its surface are a number of glacial potholes or sinks. One of them on the northern slope of Observation Hill is usually dry, its bottom being some ten feet above the level of the water in the creek. Two others on the opposite side of the hill have a much greater depth, their bottom being some thirty feet below the level of the surface of the creek. These two basins are occupied by the round bogs marked A and B on the map (Fig. 3).

The encircling ridge declines near Sphaerium Brook to an elevation of about ten feet, and then rises again sharply in a short recurrent ridge some thirty-five feet high, that projects hook-like into the basin, dividing it into two areas that are very different in character. Northward of this hook lie the round bogs, covered with sphagnum and heath formation; southward of the hook lie only grass bogs from which heaths are conspicuously absent.

This difference is probably due to differences in the character of the water supply. The round bogs receive only the drainage from the short forested slopes immediately surrounding them. This is soft water—practically rain water. Into the grass bogs, on the other hand, there is poured the drainage from long reaches of tilled fields, together with the outflow from numerous hardwater springs, that feed the brooks, inflowing from the eastward and southward. This is hard water.

Striking as is the difference in surface vegetation of these two areas, the difference in deposits below the surface is still more striking. It is also more significant. By probing the depths of any of the round bogs one finds their basins filled almost entirely with peat. Similar probing in the depths of the grass bogs reveals a surface layer of peat that is underlaid by a deep deposit of marl. This will be shown in detail in Mr. Young's report in subsequent pages.

Probably when the glacier finally retreated from this region to the southward, leaving morainal deposits encircling the basin substantially as they yet remain, the entire basin was filled with water, and the shores of the primeval Mud Pond were approximately coincident with the innermost contours of our map. It had then more than fifty times its present area of open water. It was irregular in outline, somewhat narrowed and shoaled and almost divided in the middle portion,

curving to northward beyond this, with a westwardly directed bay that was confluent with the depression that is now occupied by round bog B. Detached but adjacent to this was a small round open pond in the pothole now occupied by bog A.


FIG. 3. DR. CLAASSEN'S MAP OF 1918 SHOWING TOPOGRAPHY OF THE RIDGES AND CHARACTER OF THE BOG COVER IN MUD POND BASIN

Then the filling began, and also the cutting down of the outflow channel by Sphaerium Brook. Both processes may have gone on rather rapidly by erosion

for a little while, until the soil was firmly held by a complete ground-cover of vegetation. That there has been no very extensive cutting down of the outlet is indicated by three facts: the gradient is slight, the catchment area is small and the inflow always limited, and the channel is bedded with cobble stones, for the most part, too heavy for so small a stream to move.

The filling of the pond has been mainly the work of aquatic plants. Those growing about the shore line and on the bottom have contributed their remains in the forms of peat and marl, pushing over farther and farther into open water and adding ever to the deposits, until all that remains open at the present day is a shallow basin two hundred feet across. This is the present Mud Pond; and it is filling so rapidly that at the present rate it will be soon entirely overgrown.

Outside the Mud Pond basin, our map shows another grass bog lying in the angle between Sphaerium Brook and Beaver Creek. Though superficially similar to the other grass bogs this one is different in origin. This one was formed originally behind a beaver dam that crossed Beaver Creek some distance below its confluence with Sphaerium Brook. It appears to be maintained at the present time as the upbuilding process goes on, by flood-time accretions of silt, deposited along the bank of Beaver Creek. It is everywhere shallow, its depth where samplings have been made not being greater than eight or nine feet. It is composed of impure peat, in which from top to bottom there is a goodly mixture of woody stems, of the average size of alder stems. Apparently this bog has been little changed throughout its history. It was formed upon the level flood plain of the creek by damming, the work being done at first by beavers, and later by the natural leveeing of the creek, with increase of soil-wash from surrounding farms.

The filling of the basin is well nigh completed. The work of the plants has been supplemented and accelerated in recent times by human interference—by tillage of adjacent slopes, providing inwash materials. Only one small and shallow pond remains.

The main topographic features of the Reservation are, the pond, the streams, the ridges, and the bogs, and the last named are of peculiar interest for their unlikeness.

### Bibliography

1886. Dudley, Wm. R. The Cayuga Flora. Bull. Cornell Univ. Vol. II, pp. 132. Map.

1909. Reed, H. D., and Wright, A. H. The vertebrates of the Cayuga Lake basin. Proc. Amer. Philos. Soc. 48:370-459. Maps and diagram.

1918. Rowlee, W. W. The Relation of Marl Ponds to Peat Bogs. Brooklyn Bot. Garden. Mem. 1:410-414. Figs.

1919. Morrison, Emily Reed. The mayfly ovipositor, with notes on Leptophlebia and Hagenulus. Canad. Entom. 51:59-146, 2 plates.

1921. Lloyd, J. T. The biology of North American caddisfly larvae. Bull. Lloyd Libr. No. 21 (Entomol. Series No. 1), 119 pp., 197 figs.

1921. Needham, J. G. The New Wild Life Preserve near McLean, N. Y. Scientif. Monthly 12:246-252, 2 maps.

1926. Sibley, C. K. New species of New York caddisflies. Jour. N. Y. Entom. Soc., 34:79-91.

## SOIL SURVEY

By F. B. Howe

The mineral soils surrounding the McLean Bogs owe their origin to the weathering and alteration of terminal moraine deposits. Differences in the char-


FIG. 4. SOIL MAP OF THE RESERVATION

acter of the soil material are due almost entirely to the assorting power of the sub-glacial waters.

The Groton gravelly loam consists of a light brown or yellowish brown friable loam to a depth of about eight inches, grading into a light grayish brown

to yellowish brown gravelly loam or sandy loam. The surface is in most cases a fine loam or silt loam. The fine earth portion of the type contains a high percentage of coarse silt. Owing to the abundance of rounded, angular and subangular gravel, both coarse and fine throughout the soil section, the soil has a loose and open structure.

The substratum of the type usually consists of stratified beds of sand and gravel. The depth to the substratum is variable. The rock material composing the type is composed largely of material whose original source was considerable distance away to the north. An inventory of the rounded glacial erratics in the soil and substratum reveals a high percentage of shale, red and gray sandstone, granitic pebbles and blue limestone (Tully). Many of the pebbles and stones are covered with a coating of calcium carbonate in the form of a white incrustation.

The topography of the type is broken and morainic with a distinct kame and kettle formation.

Owing to the open, porous nature of the soil, leaching of the soluble lime has been rapid.

The presence of calcium carbonate is seldom revealed in the fine earth material in the three foot section unless limestone pebbles are present. The stratified sand and gravels occurring in the substratum, however, usually effervesce freely with HCl.

The Groton gravelly loam owing to its open porous nature serves as a reservoir for ground water and many springs occur on this soil. The springs are usually calcareous.

*Dunkirk f. s. loam.* The Dunkirk fine sandy loam consists of grayish yellow brown fine sandy loam to a depth of about seven inches. The subsoil is only slightly lighter in color than the surface soil and apparently about the same in texture. The surface soil and subsoil are usually free of stone or gravel. The substratum of the type consists of laminated fine sands usually gray in color.

The Dunkirk fine sandy loam is usually devoid of calcium carbonate in the three foot section. Lime may be found in the stratified sands in the lower substratum.

The topography of the Dunkirk fine sandy loam is decidedly morainic. Depressions or kettle holes in the Dunkirk fine sandy loam are favorable situations for the accummulation of organic plant remains. The organic deposits found in such depressions are acid in reaction.

*Organic Material.* The organic material found in the McLean Bogs varies in character. The surrounding soils have considerable influence upon the alkalinity or acidity of the deposits. Springs issuing from the hillsides to the south carry soluble calcium bicarbonate in solution. The outlet waters to Mud Pond are highly alkaline. Organic deposits occurring in inclosed basins appear to be acid. The substratum of the inclosed basins, however, is alkaline.

Positive differentiation of the organic deposits in the McLean Bogs is only possible after detailed study of the same.

*Alluvial Material.* The alluvial material or fill represents in most instances a dark brown to grayish silt loam to a depth of ten inches overlying sandy clay to heavy silt. Along the drainage the material is dark brown, high in organic matter and alkaline in reaction. Adjoining Mud Pond on the northwest the alluvial fill is mottled in the subsoil and apparently is devoid of lime in the three foot section.

## WATERS

By E. M. Chamot and F. R. Georgia *

Two very distinct types of waters are to be found in the McLean Preserve. One type comprises the acid waters of the two sphagnum bogs and the other the alkaline waters of Mud Pond, its tributaries and outlet.

The two bogs receive the run-off from water sheds that are quite small. There may also be some ground water feeding into them below the water level in the bogs but it is highly improbable that any very appreciable amount of water gets into the bogs in this manner.

The water in both bogs contains appreciable amounts of material in solution, but this material is very largely organic in nature, being derived from the decaying plant material in the bogs. The lack of inorganic salts is due to the limited extent of the water sheds over which the rain water flows before reaching the bogs.

Hydrogen ion concentration measurements show these waters to be quite acid. These measurements gave pH values ranging from 3.7 to 4.4 at different times. The acidity is undoubtedly due to a combination of free carbon dioxide and organic acids of various kinds.

The waters in Mud Pond and the streams in the remainder of the preserve are all alkaline and contain considerable amounts of mineral matter. This is to be expected since these streams are largely spring fed. The water of Argus Brook receives some drainage at times from Bog B, but this is not sufficient to make the brook acid.

The interesting thing about these waters, and especially that in Mud Pond, is the carbon dioxide equilibrium.

The large spring that feeds the inlet brook to Mud Pond, a spring that runs into Sphaerium Brook below its juncture with Argus Brook and Argus Brook itself all contain some free carbon dioxide. In the case of Argus Brook this may be due to the drainage received from Bog B.

Conditions in Mud Pond appear to vary at different periods in the year. Hydrogen ion measurements made in July indicated free carbon dioxide in part

---

* This work was done under a grant from the Heckscher Research Foundation.

of the pond with practically none in the inlet and none in the outlet. Samples taken both in August and September showed no free carbon dioxide in Mud Pond or its outlet. The hydrogen ion measurements made on Mud Pond in August showed a range of values from pH = 8.4 to pH = 9.4. Very little difference was noted between top and bottom samples of water, the chief variation being near the small inlet to the pond.

Sphaerium Brook below its union with Argus Brook may contain free carbon dioxide at times and probably does at most times a little farther down stream since it receives some spring water at this point.

It would appear that at certain times, at least, the demand for carbon dioxide in Mud Pond is sufficient to remove all free carbon dioxide from solution and possibly to draw on that held in combination as bicarbonate. Such conditions would be necessary for the deposition of marl since any free carbon dioxide in the water would tend to dissolve such deposits.

Alkalinity determinations, which are a measure of carbonates, would seem to show some utilization of carbonates in Mud Pond and thus indicate that marl is being deposited.

The inlet to Mud Pond contains small amounts of nitrates. No nitrates were found in the pond itself, but at the time were found in the outlet. It would be quite possible to have nitrates reduced in the pond itself and still have them present in the outlet for it is quite possible that the inlet short circuits into the outlet without disturbing the main body of water in the pond to any very appreciable extent unless currents are set up by the winds.

It is quite probable that differences encountered in the water in different parts of Mud Pond are the result of biological activities rather than the reverse. On the other hand physical conditions and the characteristics of the water may control the types of growth found in tne lower part of Sphaerium Brook.

## THE DEPTH OF THE BOGS

By John P. Young

The irregularities characteristic of the surface of the McLean Bog district are by soundings shown to extend below the surface level of the bogs. Two of these bogs show a depth of forty feet or more in contrast to the seventy foot height of Observation Hill. Soundings taken along the northern boundary fence in the big bog show two hollows, one thirty-eight feet deep, another twenty-five feet deep, while the ridge between them comes up to within nine feet of the surface. Other soundings taken throughout the area show the bottoms to be undulating. All of these basins except that of Bog A were once confluent. Everywhere the bottom shows first a thin layer of bluish clay which gives a lime reaction with hydrochloracic acid, as might be expected in a glaciated area like the region in question. Gradually the ponds became bogs of varying character.

Bog A is a symmetrical dish-like basin showing an extreme depth of thirty-five feet. At the edges of the sphagnum-heath area the depth is about twenty feet. The watershed of this bog is very limited and it has no inlet streams. The bluish clay bottom quickly gives way to an overlying thin layer of dark earthy matter, which in turn merges into mushy brown peat. The comparatively solid bottom layer below the peat is about two feet thick. In this bottom we find few

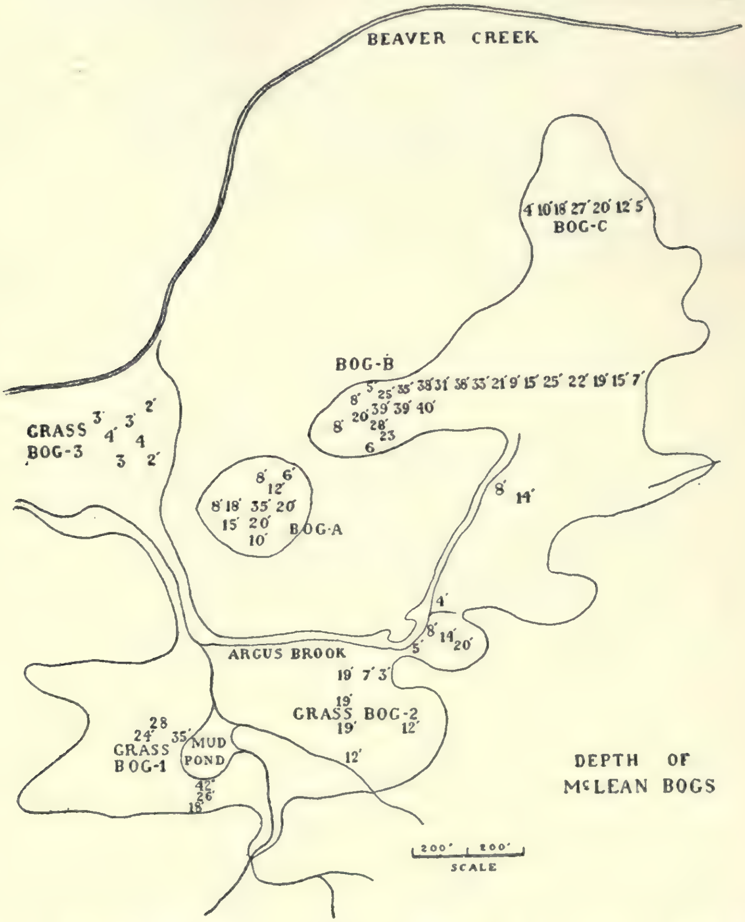



FIG. 5. MAP OF SOUNDINGS SHOWING DEPTHS OF FILLING IN THE BOG

evidences of organic life. In the peat there are a few diatoms and the usual abundance of higher plants remains. This pond or bog seems to have lost its alkaline character early in its history. The surface mat of roots is very shallow and nothing in the character of the underlying peat or the bottom gives any clue as to the cause of the variations in the surface vegetation except that the bog-heath area is over the middle and deepest part of the basin.

The southernmost basin now occupied by Mud Pond is probably the deepest of all, a depth of forty-two feet having been reached at the south edge of the pond. This basin is still supplied with an abundance of alkaline water from a stream which is the largest of any flowing into the reservation. The bottom of this basin has a thickness of about twelve feet or more with an abundance of frustules of diatoms and remains of other organic material throughout. Above this comes mushy brown peat, also full of diatoms. The deposition of this material is of course still going on in the pond.

The great bog area lying east of the two bogs mentioned above is mostly bush swamp with a considerable bog heath patch (Bog B) at its western end near Bog A and a smaller patch (Bog C) of heath near its northern end. Many trees, both deciduous and evergreen, are growing in the bush swamp. None of these surface features seem to bear any relation to the bottom contours, as the whole area is underlain with the mushy brown peat, and it is just as deep in the tree and bush covered swamp as it is in the big sphagnum-heath area (Bog B) at the western end. The maximum depth in both is about forty feet. The depth of the sphagnum-heath area at the northern end (Bog C) is twenty-seven feet. The bottom is found at greatly varying depths. It varies also in character, although the bluish clay with limy content is everywhere present as the lowest layer. Diatoms, etc., are abundant in the bottom layer and in the peat. Toward the eastern border shells are found at a depth of eighteen feet. A microscopic examination of the contents of the whole northern part of the basin shows it to be less diatomaceous than the southern (Mud Pond) part of the basin and much more so than Bog A. If the presence of diatoms indicates alkalinity, then this northern part would appear to be midway between the Mud Pond area and Bog A in character.

Grass Bog 3 is shallow, the bottom being found over most of the area at a depth of two to four feet. It shows the usual bottom layer of bluish clay, but up to this time I have been unable to get a lime reaction from it. Above the clay is a layer of decayed vegetation.

## MUD POND

By P. W. Claassen

In 1916, when the accompanying map and diagrams were made, Mud Pond covered an area of approximately six thousand square yards. Its greatest length from north to south was about two hundred and seventy-five feet and its greatest width, from east to west was just under two hundred feet. Its greatest depth was only seven feet, this being approximately the center of the pond. From the center the bottom gradually slopes up, so that near the edge of the pond the depth is not over two feet. The bottom of the pond is covered with a deep layer of soft mud and muck.

The inlet and outlet are both on the eastern side of the pond. The area between these is very shallow and warms up noticeably on hot days. It supports a dense growth of *Potamogeton pectinatus* in the open part and of Lemna in the shade of the overhanging alders. This shallow area is the habitat of a large and varied population, ranging in size from protozoa to black bass.

FIG. 6. DIAGRAM OF LINES OF SOUNDINGS IN MUD POND

At the extreme northeastern end of the pond a mere trickle of a stream enters, whose course through the bog is so obscured by sedge tussocks that it has been named Lost Brook.

The main part of the pond is of fairly even depth with the temperature remaining low throughout the summer. There is a sparse growth of *Potamogeton pectinatus* and *P. pusillus* which reach their maximum growth in August. Near the southern edge are beds of the horn wort, *Ceratophyllum demersum.*

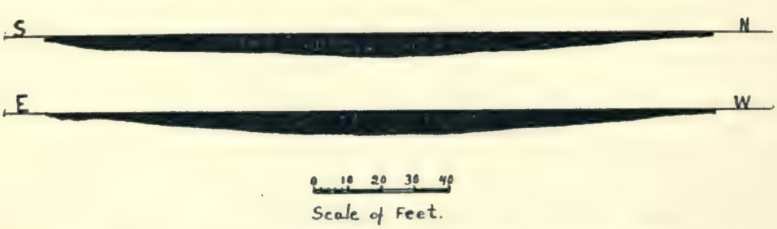



FIG. 7. TWO CROSS SECTIONS OF MUD POND, 1916

The edge of this basin near Inlet Brook is nearly devoid of animal life because of the quantities of sawdust deposited there. The clumps of swamp loosestrife, Decodon, occur in shallow water around the borders of the pond and

furnish support for the tubes of numerous midge larvae and the cases of pupating Trichoptera.

Beds of Chara occur close to the banks in shallow water and are the favorite habitat of certain beetle larvae of the genus Haliplus and of the larvae of the caddisfly Triaenodes. Much of the vegetation of the pond is heavily incrusted with lime. In the shelter of the marginal tussocks of sedge and Decodon occurs a little floating duckweed.

The pond has a hanging border of bog-cover, which consists of sphagnum and other mosses, sustained on a scaffolding of sedge and grass and alder roots. This border sinks noticeably under foot, when one approaches the water's edge.

## THE STREAMS

By C. K. Sibley and D. J. Leffingwell

The streams in which careful collecting has been done are the following:

*Inlet Brook.* Hard water springs on the hills to the south of the preserve feed this small stream, which is the principal source of water for Mud Pond. Being a short stream and shaded throughout its length, the brook waters are cold during the summer. Probably because of this, insects living in Inlet Brook emerge two weeks later than other members of the same species living in the other brooks of the reservation. The bed of Inlet Brook contains but few stones. The bottom is mainly of sand with bars of silt in slack water. There is also a large amount of dead leaves, and bark, and wood fragments. In addition, the hemlocks on the ridge just outside of the preserve were lumbered a few years ago and much of the sawdust found its way into this stream. Within the preserve the stream has an even, moderate current.

*Sphaerium Brook.* This is the outlet of Mud Pond. This is the stream that has cut through the rim of the basin, and that conducts all the off-flowing water into Beaver Creek. It divides naturally into three parts:

1. An upper section some hundred and seventy-five yards long within the limits of the original basin. Here current is almost lacking, and the bottom is very soft black muck. Here, buried in the muck, is a phenomenal bed of little viviparous white clam, *sphaerium sulcatum,* that has given the stream its name. The clams are almost as abundant in this muck as are plums in a plum pudding; and their dead shells besprinkle the surface of the bed for some distance down stream. A few burrowing insects, the nymphs of Hexagenia, Ephemera and Gomphus, are also common here.

2. A middle section some two hundred yards long traverses the rim of the basin. Here it flows with a distinct current over a gravelly bed. Here the fauna is entirely changed. The big mussel, Lasmigonia, replaces Sphaerium. A rich

population of lotic animals of many sorts is present. They find shelter among its stones and on its logs and leafdrifts. Most characteristic of its logs are perhaps the beetles Psephenus and Macronychus; the fishfly, Nigronia; the dragonfly, Boyeria; the stonefly, *Perla copitata;* the mayflies, Heptagenia; and many caddisflies, as our list on subsequent pages will show. On the gravelly bottom crawfishes sprawl, and nymphs of the mayflies Baetis dart about, and in it the larvae of the orlfly, Sialis, burrow. One of the very few known localities for the mayfly, *Leptophlebia betteni,* is a few rods length in the middle portion of this section.

3. A longer lower section, lying outside the basin, winds across the plain that was once a beaver meadow and empties into Beaver Creek. Here the current slackens again and the bottom is soft mud. In the softest of it nymphs of the big sprawling dragonfly, *Cordulegaster diastatops,* abound. The nymphs of Gomphus and of Hexagenia burrow, and a few scuds, Hyalella, clamber amid the leaf drifts. Of the three sections, this one seems to have the scantiest population.

*Argus Brook.* Just within the basin a small stream enters Sphaerium Brook. This stream, a mere rill, two to three feet wide, is Argus Brook, so named because of a large caddisfly, *Astenopylax argus,* whose larva is found in its waters. The brook rises in the bush swamp to the eastward, and in its upper reaches consists of a series of pools between clumps of red osier dogwood and alder. Then it develops a gentle current and a distinct channel and flows along the edge of the filled pond basin following the basal contour of the Hook. The bottom, through this part of its course, is of sand with numerous silt bars and deposits of wood fragments. Where the stream joins Sphaerium Brook, the bottom is of soft mud with the tubes of the caddis worm, *Phylocentropus lucidus,* very common along the sides of the channel.

*Beaver Creek.* Into Sphaerium Brook flows this much larger stream. It rises about two miles to the east of the preserve and is rapidly enlarged by the water from a group of big springs. For a short distance below these springs it flows over a rocky bottom. Here, in a limited area, the caddisfly larva, *Bracnycentrus nigrosoma* is very common. However, the valley soon widens, and the stream character changes. The bottom is of mud and sand and the channel is obstructed by logs. But little collecting has been done in this stream.

*Gyrinophilus Springs.* The large springs mentioned above are five or six in number. They flow from the sides of a blind valley and join to make a considerable stream. The purple salamander, *Gyrinophilus porphoryticus,* is found in some of these springs; hence the name used in some of the lists that follow in this paper. They have been known to the botanists merely as the Big Springs. The red alga, Batrachospermum, and various lime encrusting algae grow on the stones where they are barely covered by the thin sheet of water. Sundew is common in the bottom of the valley. The springs are also interesting because of the presence there of the larvae of certain Microtrichoptera.

# THE BOG COVER

By James G. Needham and P. W. Claassen

The round bogs were once doubtless open circular ponds. They are now completely overgrown. Bogs A, B and C are very similar, though the filling of C is a little more advanced. Each has a central area of dense low-growing sphagnum and heath, surrounded by two zones of larger woody plants. First is a narrow zone of shrubs, and second a wide zone of water-loving trees—yellow birch, red maple, black ash, etc.,—extending to the foot of the slope. The latter zone is now a cut-over area, studded with stumps of trees only, among which the shrubbery of the first zone, tall ferns and other shade plants, brambles and other immigrants are all struggling lustily for place and standing room. A few scattering, worthless trees remain, having escaped the axe.

The more shoal areas of the remainder of the basin, and all the principal areas of silt deposition, whether originally shallow or not, are covered with bush swamp, the dominant species in which is the speckled alder. This alder grows luxuriantly along the silt-strewn edges of all the brooks and about the borders of Mud Pond. Under its shadow in the wetter places grow acres of marsh marigold and skunk cabbage interspersed with swamp saxifrage, and in the plashy edges of the interrupted streamlets, the spreading chrysosplenium. The alder grows in spreading clumps of usually four to eight strong stems, which gather fallen twigs and leafage about their bases, and thus build up miniature islets in the swamp. On the summit of these, such plants as meadowrue, and marsh fern, and bedstraw, and red raspberry find lodgment. The older outer stems of the alder clumps, being loosely anchored in the mud, are borne down to the ground by the heavy ice-coats of winter, and new shoots from the center of the clump arise in their stead. Thus the holding unit is maintained. The alder is the most important plant in the later stages of land building in the basin. The grass bogs are merely the openings in the herbaceous bog-cover that are not yet overgrown by alder or other shrub. The largest of these are the two that lie in the southern part of the basin. They are situated on either side of the pond, but separated from it and from each other by the shore-bordering alders. They are designated hence as Grass Bogs Nos. 1 and 2.

*The Round Bogs.* Bog A, as will be noticed on the map, is entirely surrounded by higher ground, so that it has no drainage. It is flooded in the spring after the snow melts, and always is the wettest bog. For this reason it may be the last bog to be grown over.

Bogs B, C, and the remnant between, were probably formerly part of one large bog. Now, Bog C is fast disappearing, and Bog B is invaded by chokeberry and mountain holly. These bogs are part of the area drained by Argus Brook, and so, are much drier than Bog A. Even though the summer of 1924 was fairly wet, the sphagnum in Bog B died at the tips during August. The quantity of

water rather than the character of the water may determine the future of these bogs. It is readily noticed that all the heaths have a more luxuriant growth here than in Bog A.

The one plant that everywhere forms a complete cover over all these bogs is Sphagnum. The two plants that come next in uniformity and ubiquity of distribution are the two heaths, Andromeda and Chamaedaphne, whose intertwined roots support the Sphagnum. These three really make a bog-cover. Labrador tea is locally common, and the cranberry, a diminutive heath, trails over the surface in patches. Scattered stems of cottongrass rise spindling here and there, waving their wooly crowns rather conspicuously when in fruit.


FIG. 8. DIAGRAM SHOWING SPATIAL RELATIONS OF THE PRINCIPAL PLANTS IN THE SPHAGNUM AND HEATH FORMATION OF THE ROUND BOGS

It may be noted further that at the present time (1925) leatherleaf (Chamaedaphne) ranks first in order of abundance of the heaths. In Bog A leatherleaf is tallest and thickest around the outer border. It is somewhat lower,

but almost as abundant over the eastern half of the bog, but still lower and much more scarce just west of the middle. Bog rosemary (Andromeda) occurs most abundantly in patches on the west side, but occurs scatteringly over most of the bog, being quite common along the eastern area. Labrador tea (Ledum) occurs in this bog only along the east edge near the shrub zone and is rather rare except in one or two small patches in the southeast corner. Cranberry (Vaccinium) occurs as a thick undergrowth everywhere except along the northern border. Cottongrass (Eriophorum) occurs scatteringly throughout the bog, but more abundantly in the area of lower growth just west of the center where the leather-leaf is scarcer. Very few pitcher plants (Sarracenia) are present in this bog.

The cover of Bog B differs from Bog A chiefly in the fact that the leather-leaf is almost uniform in height and distribution, and Labrador tea is much more abundant. Cottongrass is less common. Bog rosemary is scattered more or less throughout the entire bog, but occurs abundantly in patches near the center and along the northern portion. Cranberry is much less abundant than in Bog A. Pitcher plants are quite common in this bog.

The spatial relations that these plants bear to each other in this open area of the bog are shown in the accompanying diagram (Fig. 8). Note the uniform layer of vertical unbranched stems of Sphagnum; the cranberry, trailing over it and rooting shallowly below the green and living Sphagnum in the uppermost, new-formed peat; the strong supporting framework formed by the roots of the larger heaths; and the deep vertical penetration of the slender roots of cotton-grass. Other plants not shown in the diagram are found here and there; the slender, grass-like, beaked rush, Rynchospora, the pitcher plant, Sarracenia, a few orchids and a sedge.

For the purpose of establishing data by means of which the progress of the filling process may in the future be measured, the following measurements have been made (November, 1925).

Diameter Bog A, east to west, 210 feet; north to south, 160 feet
Diameter Bog B, east to west, 175 feet; north to south, 180 feet
Diameter Bog C, east to west, 50 feet; north to south, 60 feet

*The Grass Bogs.* The grass bogs are far less uniform in the character of their vegetation than are the round bogs. Their meadow-like appearance is due to the dominance in them of several species of tussock-forming grasses and sedges. These species are of local and irregular distribution, and rarely occur in anything like a pure stand. Where the tussocks are highest—often knee high or higher, so that walking among them is no easy matter—their height is increased by at least two animal agencies: the ants of the marsh build their nests in the top of the tussocks, and in so doing heap up much material on their summits; the meadow mice excavate runways in the bottom of the narrow channel between the tussocks

and eat new shoots springing from severed stems, and thus they deepen the narrow lanes between the tussocks.

Many of the large tussocks are inhabited by ant colonies. In building up the nest the ants bring up peat and the vegetable material until the tussock has risen far above the level of the water within the bog. These tussocks, with their tops high and dry, furnish a foothold for clumps of alder, dogwood and other plants which otherwise might be unable to establish themselves in such wet situations. It is, therefore, very apparent that the mice and more particularly the ants are important agencies in bringing about plant succession. Of the three species of ants formed in the tussocks, *Formica fusca* was the most common. The other two species are *Tapinoma sessile* and *Lasius immoratus,* subsp. *mixtus,* var. *aphidicola.*

The grass bogs lack the heaths of the round bogs, but they contain areas having a considerable admixture of sphagnum with here and there an overgrowth of cranberries. There are marsh ferns in plenty; and in a wet spot in the largest one a bit of cattail has obtained a foothold. The edges of all the grass bogs are being invaded by alder.

As a means of measuring the progress of this invasion, a strip (see map on page 178) thirty feet in width crossing the middle of Grass Bog No. 2 from north to south, was studied in 1918 and again in 1925. The accompanying diagram

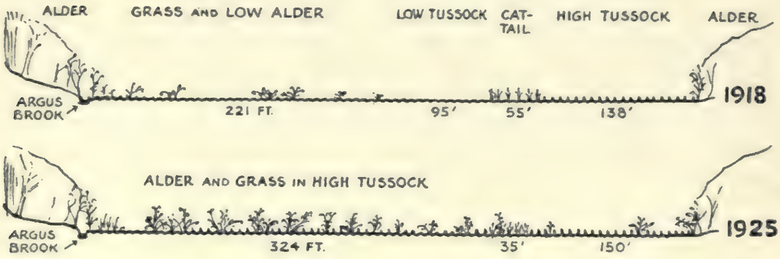



FIG. 9. DIAGRAM SHOWING THE INVASION OF GRASS BOG NO. 2 BY ALDER IN SEVEN YEARS

shows roughly the conditions found. More than half of this strip was practically free from woody plants in 1918. A wet spot in the midst of it was filled with cattails (Typha), to the south of which was a grassy area of high tussocks, and to the north of which was a sedgy area of low tussocks. Seven years later alders were established in all these areas and only narrow strips of meadow remained. The cattails were being crowded out (a dozen fruiting spikes appearing singly here and there on the reduced patch); instead of the glaucous sedge in low tussocks, bluejoint grass was growing everywhere among the alders, and the highest of them bore also numerous tall canes of Joepye weed. These wet meadows thus seem to be passing rapidly over into alder swamp.

# ABBREVIATIONS

The lists which follow represent our present knowledge of the plants and animals of the reservation. The large forms are, of course, best known. Some of the lower groups have not yet been studied there. Some notes on habitats and associations, additional to that given in the preceding pages and appropriate to the several groups, will be found in the introductions to the several lists. The abbreviation of locality names used in the lists are those given below, and shown on the map (Fig. 10).

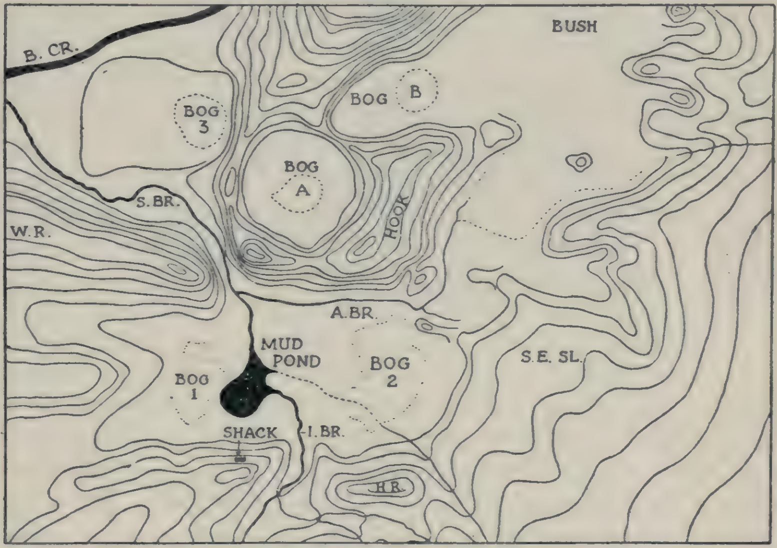



FIG. 10. MAP SHOWING THE PRINCIPAL LOCALITIES MENTIONED AND ABBREVIATIONS USED IN THE LISTS WHICH FOLLOW

Grass Bog 1, *abbr.* Bog 1
Grass Bog 2, *abbr.* Bog 2
Grass Bog 3, *abbr.* Bog 3
Round Bog A, *abbr.* Bog A
Round Bog B, *abbr.* Bog B
Round Bog C, *abbr.* Bog C
Argus Brook, *abbr.* A. Br.
Inlet Brook, *abbr.* I. Br.
Beaver Creek, *abbr.* B. Cr.
Sphaerium Brook, *abbr.* S. Br.
Mud Pond, *abbr.* Mud P.
Hemlock Ridge, *abbr.* H. R.
Hook, *not abbr.* Hook
S. E. Slope, *abbr.* S. E. Sl.
West Ridge, *abbr.* W. R.
Shack, *not abbr.* Shack
Bush Swamp, *abbr.* Bush

# FLORA AND FAUNA

## VASCULAR PLANTS

(PTERIDOPHYTA AND SPERMATOPHYTA)

By K. M. WIEGAND, A. J. EAMES AND OTHERS

Botanical explorations in the McLean Bogs began with the founding of Cornell University. The group of young students interested in plant and animal life, who were brought together here through the influence of university environment, soon realized the interesting features of the McLean Region. In 1886, Professor W. R. Dudley, then a member of the university staff of the botany department, published a catalogue of the Phanerogamic plants of the Cayuga Lake Basin, bringing together the records of all the early explorations of this region, as well as his own extensive personal observations. In this catalogue mention is made of the botanical richness of the McLean Region (the bogs proper of which he called "the Round Marshes") and the rare plants then known to occur were mentioned. Throughout the text also are records of the occurrence of large numbers of our less common plants at McLean. Since the publication of the Dudley catalogue many botanists from the University have visited McLean and classes have been conducted to these bogs almost every year. During the past few years, in connection with a survey of the flora of the Cayuga Lake Basin, looking toward a new catalogue of that region, the McLean bogs have been studied with renewed activity. The present list of plants known to occur within the preserve has been compiled from records left by these various explorations in the past to which have been added some special records made on recent visits to the bogs.

From the standpoint of the vascular plants, the McLean Preserve is one of the richest areas of its size in this vicinity. From the distributional standpoint, the units of most contrast are: (1) the upland woods; (2) the swamp land; (3) the calcareous meadows; (4) the acid peat bogs; (5) the upland open ground.

The forest surrounding the McLean Bogs is of the beech-birch-sugar-maple type. Following the general condition, incident to this type, the shade is very dense in midsummer with a consequent dearth of vegetation on the forest floor. In the spring, however, woodland carices, violets and other spring humus plants are abundant with the white and red trillium as characteristic plants. True Carex laxiflora, Poa saltuensis and Viola Selkirkii are among the rarer species. Around Mud Pond and the southeast slope the soil is rich with muck humus. On the point of West Ridge, however, there is a slight tendency in the soil towards the chestnut-oak type, bringing in such plants as Pedicularis canadensis, Galium lanceolatum, Solidago latifolia and S. arguta; though chestnuts, oaks, desmodiums,

lespedezas and the dwarf vacciniums—plants characteristic of the well-developed chestnut-oak associations—are absent.

Around the bogs, connecting them with the upland and each other is usually an area of wooded swamp of red maple, black ash, hemlock and other trees. Viburnum lentago, Nemopanthus mucronata, Ilex verticillata, Vaccinnium corymbosum, willows and alders fill in between the trees. On the forest floor are innumerable mossy logs. Cinnamon fern is everywhere abundant. Ribes triste, var. albinervium, R. prostratum and Carex riparia are frequent, while Calla palustris is occasional. Between bogs B and C is a raised area where Trillium cernuum finds its only home in the Cayuga Lake Basin.

The regions marked 1, 2, 3 and C on the map are calcareous as to soil reaction. The first three are strongly so, being underlaid with marl and are really marl meadows, but C is somewhat transitional to the peat bog and the swamp. The openings on these are populated primarily by calciphile sedges and grasses, with a marked absence of the ericaceous vegetation so characteristic of the acid peat bogs. Around the open areas are thickets of calciphile shrubs. Characteristic of these calcareous areas are Calamagrostis canadensis, Carex aquatilis, C. stricta, C. diandra, Rhamnus alnifolia, Galium labradoricum, Arenaria laterifolia, Cardamine pratensis and Menyanthes trifoliata. In some spots sphagnum occurs and also local colonies of Vaccinium macrocarpon as well as individual shrubs of Vaccinum corymbosum. Amelanchier intermedia and Rubus hispidus grow in this shrub zone as well as about the acid bogs. Alder, however, is the dominant shrub of the transition zone. In Bog C, Eriophorum callitrix is abundant, and a rare willow, Salix serrissima, is found.

The acid peat bogs are two in number (labelled on the map Bogs A and B). Without doubt at some earlier time a body of open water occupied the center of these bogs, but now the whole surface is covered by a typical open moor supporting the regular acid bog flora and underlaid with peat (or sometimes also with marl below the peat). Bordering these bogs are successive zones of characteristic shrubs making the transition to the uplands adjoining. On the moor occur such heaths as Chamaedaphne, Andromeda, Ledum and Vaccinium oxycoccus with a few orchids such as Calopogon and formerly Pogonia. Rynchospora alba, Eriophorum virginicum and Carex pauciflora flourish in these bogs and a few Sarracenias are scattered about. Sundews of the "rotundifolia" type are frequent. A dense mat of Sphagnum, represented by several species, forms the general covering of the bogs.

The zone transitional to the peat bogs is made up of dense tangles of Vaccinium corymbosum, V. canadense, Viburnum cassinoides, Nemopanthus mucronata, Amelanchier intermedia, Ilex verticillata and young red maples, with plenty of Rubus hispidus. Carex canescens is common in this zone. Rubus jacens is a characteristic plant of the zone and found nowhere else in the Cayuga Lake Basin except at the nearby Chicago Bog.

## Division Pteridophyta

### *Family Polypodiaceae (Fern Family)*

[Cystopteris bulbifera (Bulblet-bearing Bladder Fern). Low woods along Beav. Br. toward Chicago. Not yet found in the preserve.]

Onoclea sensibilis (Sensitive Fern). Swamp around Mud P.; probably elsewhere.

Thelypteris palustris (Marsh Shield Fern). Boggy soil: Mud P.; Grass B. 2; Bog C.

T. noveboracensis (New York Fern). Upland woods: around Mud P.

T. marginalis (Marginal Shield Fern). Dry woods: Obsv. Hill; Hem. Ridge.

T. cristata (Crested Shield Fern). Swamps: Mud P.; Bog 3; probably elsewhere.

T. cristata, var. Clintoniana (Clinton's Fern). Swampy places, infrequent: s. w. entrance to preserve.

T. Bootii (Boott's Fern). Low thickets, occasional: near Sphaer. Br.; near Argus Br.; near Bog C. This form in recent years has generally been considered to be a hybrid of T. cristata and T. spinulosa, var. intermedia.

T. spinulosa, var. intermedia (Spiny-toothed Shield Fern). Upland woods: around Mud P.; West Ridge; around Grass B. 2.

Polystichum acrostichoides (Christmas Fern). Upland woods: around Mud P.

Dennstaedtia punctilobula (Hay-scented Fern). Upland woods: around Mud P.; n. w. corner; probably elsewhere.

Athyrium angustum (Lady Fern). Low woods: around Mud P., and elsewhere.

Adiantum pedatum (Maiden-hair Fern). Upland woods: around Mud P.

Pteridium latiusculum (Brake). Common on dry ridges: Obsv. Hill; Grass Bog 3, and elsewhere.

### *Family Osmundaceae (Flowering Fern Family)*

Osmunda regalis, var. spectabilis (Royal Fern). Swamps: various localities.

O. Claytoniana (Interrupted Fern). Low thickets: south of Mud P.; around Grass B. 3.

O. cinnamonea (Cinnamon Fern). Swamps: around Bog A, and Grass B. 2, and elsewhere.

### *Family Ophioglossaceae (Adder Tongue Family)*

[Ophioglossum vulgatum (Adder-tongue Fern). Damp pastures between the bogs and the railroad, outside the preserve. A rare plant in this region.]

Botrychium matricariaefolium (Matricary Fern). Dry thickets, scarce: Obsv. Hill.

B. angustisegmentum (Lance-leaved Grape Fern). Dry thickets, scarce: West Ridge.

B. dissectum, var. obliquum (Dissected Grape Fern). Damp banks, scarce: hill near Bog A; near east line.

B. virginianum (Common Grape Fern, Rattlesnake Fern). Upland wood, frequent: around Mud P., and elsewhere.

### *Family Equisetaceae (Horsetail Family)*

Equisetum arvense (Common Horsetail). In diverse habitats, scarce; along south line.

E. hyemale, var. affine (Scouring Rush). Upland woods, scarce: e. of Mud P.; near Sphaer. Br.

[E. scirpoides (Small Scouring Rush). Damp banks in woods: Beav. Br. toward Chicago. Not found within the preserve.]

### *Family Lycopodiaceae (Club-moss Family)*

Lycopodium lucidulum. Damp woodlands, frequent: e. of Mud P.

L. annotinum, var. acrifolium (Ground Pine). Dry woods, scarce: between Sphaer. Br. and Bog A.

L. clavatum (Ground Pine). Dry woods, scarce: between Sphaer. Br. and Bog A; s. e. woods.

L. obscurum (Ground Pine). Dry woods, frequent: between Sphaer. Br. and Bog A; between Bog A and Bog B; Obsv. Hill, and elsewhere.

L. complanatum, var. flabelliforme (Ground Pine). Dry woods, scarce: between Sphaer. Br. and Bog A.

[L. tristachyum (Ground Pine). Open place just n. of preserve. Rare in this region.]

## Division Spermatophyta

### Subdivision Gymnospermae

### *Family Taxaceae (Yew Family)*

Taxus canadensis (American Yew, Ground Hemlock). Low woods, frequent: around grass B. 3, and elsewhere.

### *Family Pinaceae (Pine Family)*

Pinus Strobus (White Pine). Scattered about the preserve but infrequent.

Tsuga canadensis (Hemlock). Upland and lowland woods, common.

SUBDIVISION ANGIOSPERMAE

Class Monocotyledoneae

*Family Typhaceae (Cattail Family)*

Typha latifolia (Cattail). Marshland, scarce: s. e. of Mud P.; east line.

*Family Sparganiaceae (Bur-reed Family)*

Sparganium americanum (Bur-reed). Mucky swampland, rare: Sphaer. Br. near w. line.

*Family Najadaceae (Pondweed Family)*

Potamogeton pusillus. In Mud P.

P. pectinatus. In Mud P.

*Family Alismaceae (Water-plantain Family)*

Alisma Plantago-aquatica (Water-plantain). Mucky swampland, rare; recorded but without station. Whether the typical form or var. parviflora is not stated.

Sagittaria latifolia (Arrow-leaf). On the mud around edge of Mud P.

*Family Gramineae (Grass Family)*

[Bromus Kalmii (Downy Wild Brome Grass). Low woods: Beav. Br. Not yet found within the preserve.]

B. ciliatus (Wild Brome Grass). Calcareous bogs: Mud P.

Bromelica striata (Purple Oat). Dry upland woods, frequent: n. w. of Mud P.; s. e. woods.

Festuca elatior (Meadow Fescue). High ground: scattered stations.

F. nutans (Nodding Fescue). Dry woods: n. w. of Mud P., and probably elsewhere.

[Glyceria melicaria (Long Manna Grass). Mucky woods, rare: upper Beav. Br. Not found within the preserve.]

G. nervata (Fowl Meadow Grass). Swamps, common: scattered stations.

G. nervata, var. stricta. Near Mud P.

G. grandis (Reed Meadow Grass, Tall Manna Grass). Swamps, scarce: s. e. of Mud P.

G. Fernaldii (Pale Manna Grass). Swales, rare: near Mud P.

[Poa annua (Low Spear Grass). Should be found along paths.]

P. compressa (Wire Grass, Flat-stemmed Meadow Grass, Canada Blue Grass). Dry woods and openings, scarce: Obsv. Hill; n. w. of Mud P.

P. saltuensis (Nodding Spear or Meadow Grass). Dry woods, frequent: Mud P.; Bog 3, and elsewhere.

P. paludigena (Bog Spear or Meadow Grass). "Round Marshes" (Dudley). It has not been found recently, but should occur in the calcareous open swamps.

P. alsodes (Woodland Spear Grass). Dry woods, very common and generally distributed.

P. trivialis (Rough Meadow Grass). Low woods, occasional: s. of Mud P.

P. pratensis (Kentucky Blue Grass, June Grass). Upland open places, frequent.

P. palustris (P. trivialis, False Red-top, Fowl Meadow Grass). Swamps, frequent: Mud P., and elsewhere.

[P. nemoralis. Woods, upper Beav. Br. Not noted within the preserve.]

Dactylis glomerata (Orchard Grass). Road borders and open grassland, occasional.

Agropyron repens (Quack Grass). Grassland, occasional.

Elymus virginicus (Wild Rye Grass). Swamp and stream borders: Bog 3.

Asprella Hystrix (Bottle-brush Grass). Dry woods, scarce: s. of Mud P.

Sphenopholis pallens. Moor of Mud P.

Danthonia spicata (Wild Oat Grass). Dry open places, frequent: Obsv. Hill.

Calamagrostis canadensis (Blue-joint Grass). Grass marshes, common.

[Agrostis alba (Red-top). Not yet found, but should occur within the preserve.]

A. tenuis (Slender Red-top). Dry banks, scarce: Obsv. Hill.

[A. hyemalis (Hair Grass). Should be found on logs and hummocks around bogs.]

Cinna latifolia (Wood Reed Grass). Swamps, occasional: near Mud P.

Phleum pratense (Timothy). Highlands, occasional.

Muhlenbergia foliosa (Drop-seed). Bog borders, scarce: west side of Grass B. 3.

M. racemosa (Bog Drop-seed). Calcareous grass bogs, occasional; Grass B. 3.

Dilepyrum erectum. Upland woods, scarce: around Mud P.

Milium effusum (Wild Millet Grass). Low woods: around most of the bogs.

Leersia oryzoides (Cut Grass). Swamps: along e. line.

Oryzopsis asperifolia (Mountain Rice). Dry woods, scarce: n. w. of Mud P.; Obsv. Hill.

Anthoxanthum odoratum (Sweet Vernal Grass). Dry woods and openings, occasional: Mud P.

Echinochloa crus-galli (Barn-yard Grass). Waste places, scarce: near s. entrance.

E. frumentacea (Barn-yard Millet). Spontaneous: s. of Shack in 1925.

Panicum capillare (Old-witch Grass). Waste ground, rare: near Shack.

P. Lindheimeri, var. implicatum (Panic Grass). Dry open grassy places, scarce: near Shack.

Setaria lutescens (Yellow Foxtail). Waste ground, rare.

### *Family Cyperaceae (Sedge Family)*

[Cyperus rivularis. Sand and gravel bars; upper Beav. Br.]

Dulichium arundinaceum. Swales, scarce: around bog, s. of Shack.

Eleocharis obtusa (Spike Rush). Swales, scarce: s. e. of Mud P.

E. palustris (Perennial Spike Rush). Boggy soil, scarce: Mud P.

E. intermedia. Mucky soil, rare: moor of Mud P.

Scirpus hudsonianus. Calcareous boggy thickets, rare: Bog C.

S. atrovirens, var. georgianus. Marshes and bog borders, scarce: along e. line.

[S. lineatus. Open low pasture, n. of bogs.]

S. cyperinus (Brown Wool Grass). Swamps, marshes and bog borders, frequent. Highly variable, but the varieties occurring in the preserve have not been worked out.

Eriophorum callitrix (One-spiked Wool or Cotton Grass). Boggy soil, rare but locally abundant: Bog C.

[E. gracile (Wool or Cotton Grass). May occur in the bogs.]

E. viridi-carinatum (Broad-leaved Wool or Cotton Grass). Boggy soil, rare: Bog C.

E. virginicum (Late Wool or Cotton Grass). Acid bogs, frequent: Bogs A and B. A characteristic plant of these bogs in late summer.

Rynchospora alba (White Beak-rush). Acid bogs, frequent: Bogs A and B.

Carex leptalea. Boggy soil, occasional: moor of Mud P.

C. pauciflora. Acid bogs, scarce: Bogs A and B.

C. stipata. Swamps and swales, frequent: Mud P., and elsewhere.

C. laevivaginata. Swamps and swales, occasional: s. e. Mud P.

C. convoluta. Dry woods, scarce: around Mud P. and Bog A.

C. rosea. Dry woods, common: around Mud P. and Bog A., and elsewhere.

C. cephaloidea. Dry rich woods, scarce: e. line.

C. sparganoides. Rich woods, scarce: n. w. of Mud P.; foot of Obsv. Hill.

C. vulpinoidea. Swamps, occasional: s. e. of Mud P.

C. diandra. Moor of Mud P.

C. prairea. Moor of Mud P.

C. Deweyana. Dry woods, frequent: around Mud P.; Obsv. Hill, and elsewhere.

C. bromoides. Around bogs, frequent: Mud P., and elsewhere.

C. tenella. Thickets around bogs, occasional.

C. trisperma. Sphagnum bogs, probably frequent: Bog A.

Carex canescens. Sphagnum bogs, probably frequent: Bog A.

C. brunnescens. Upland woods around bogs, frequent: Mud P.; Bog A.

C. interior. Low thickets around bogs, common: Mud P.; Grass B. 3; Bogs A and B, and elsewhere.

C. Howei. Low thickets around bogs, frequent: Bog A; also near n. line.

[C. tribuloides. Should be found in the preserve.]

C. projecta. Low woods, occasional: Mud P.; Grass B. 3.

C. scoparia. Swales and meadows, frequent: near Mud P.; Bog A; n. line.

C. Bebbii. Meadows and bog borders, scarce: near Mud P.

C. alata. Bog borders, rare: Mud P.

C. aquatilis. Calcareous bogs, scarce: Mud P.

C. stricta. Grass bogs and meadows, very common.

C. crinita. Thicket around Bog B.

C. pallescens. Low grassland, scarce: path leading into Mud P.

C. Swanii. Dry woods and banks, scarce: Mud P.

C. scabrata. Low woods s. and e. of Mud P.; Sphaer. Br.

C. pennsylvanica. Dry woods and banks, frequent: around Mud P.; n. line, and elsewhere.

C. communis. Dry woods, frequent: around Mud P.

C. pedunculata. Dry woods, frequent: w. Ridge.

C. plantaginea. Dry banks and woods, occasional: Mud P.; Hem. Ridge.

C. laxiculmis. Dry woods, frequent: n. w. of Mud P.; near Sphaer. Br.

C. blanda. Damp woodlands, scarce: around Mud P.; e. line.

C. laxiflora. Damp woodlands: Sphaer. Br. to Mud P.; locally abundant.

C. anceps. Damp or dry woods, frequent.

C. leptonervia. Borders of swamps, frequent.

C. granularis, var. Haleana. Low woods, scarce: Mud P.; Grass B. 3.

C. grisea. Low woods, scarce: Sphaer. Br.; Mud P.

C. arctata. Dry woods, rather common.

C. debilis, var. Rudgei. Upland open woods, scarce: Hem. Ridge.

C. gracillima. Rich damp woods, frequent: Mud P., and elsewhere.

C. flava. Calcareous meadows and thickets, scarce: Mud P.; marl springs.

C. lanuginosa. Calcareous meadows, scarce: Mud P.; Grass B. 1.

C. riparia, var. lacustris. Swales and meadows, locally abundant: Bog C; swale e. line, and elsewhere.

C. hystericina. Swales, scarce: Mud P.; near Hem. Ridge.

C. Schweinitzii. Swales, scarce: Mud P.; near Hem. Ridge.

C. lurida. Swales and swamps, scarce: around Mud P.

C. intumescens. Swamps around Mud P., and elsewhere. Most of the material is of the typical form rather than var. Fernaldii.

C. intumescens, var. Fernaldii. Around Bog B; s. of Mud P.

### *Family Araceae (Arum Family)*

Arisaema triphyllum (Jack-in-pulpit, Indian Turnip). Low woods, frequent: around Mud P., and elsewhere.

A. triphyllum, var. Stewardsonii. Boggy soil, frequent throughout.

Symplocarpus foetidus (Skunk Cabbage). Boggy woods, common.

Calla palustris (Wild Calla). Boggy woods, scarce: Bog B; e. line.

### *Family Lemnaceae (Duckweed Family)*

Lemna minor (Duckweed). Floating in Mud P. and Sphaer. Br.

### *Family Juncaceae (Rush Family)*

Juncus effusus, var. solutus (Common Rush). Low woods and thickets, common: near n. line.

J. effusus, var. Pylaei. Similar situations, scarce: around Bogs A and C; e. line.

[J. bufonius. Should be found.]

J. tenuis (Path Rush). Damp woods and paths, frequent: Mud P.; between Bogs A and B.

J. Dudleyi. Springs and wet places in calcareous soils, scarce: n. e. of Grass B. 2; near Bog C. [Various places just outside of preserve.]

Luzula saltuensis (Wood Rush). Rich upland woods, occasional: around Mud P.; s. e. slope.

### *Family Liliaceae (Lily Family)*

Veratrum viride (American Hellebore). Low woods and fields, frequent: Mud P.; Sphaer. Br.; n. w. corner.

Uvularia grandiflora (Large Bellwort). Rich woods, rare: s. e. slope.

Oakesia sessilifolia (Sessile Bellwort). Woods, rare: Obsv. Hill; e. line.

Allium tricoccum (Wild Leek). Rich woods, scarce: near Bog A; e. line, abundant.

Lilium canadense (Canada Lily, Meadow Lily). Low woods and marshes, occasional: around Mud P.; around Grass B. 3.

Erythronium americanum (Adder-tongue, Dog-tooth Violet). Woods, fairly common.

Clintonia borealis (Clintonia). Woods, fairly common.

Smilacina racemosa (False Solomon's Seal, False Spikenard). Rich woods, frequent: Obsv. Hill; s. e. Mud P., and elsewhere.

S. stellata (False Solomon's Seal). Calcareous bogs and swales, scarce: Mud P.; Grass B. 3.

Maianthemum canadense (False Lily-of-the-valley). Dry woods, common.

Streptopus roseus (Twisted Stalk). Upland woods, scarce: around Mud P.

Polygonatum pubescens (Smaller Solomon's Seal). Dry, rich woods, scarce: around Mud P.

Medeola virginiana (Indian Cucumber Root). Rich woods, frequent: around Mud P.; by n. line.

Trillium cernuum, var. macranthum (Nodding Trillium). Low pine woods, locally frequent: Trillium Grove s. of Bog C. This is the only station in the Cayuga Lake Basin.

T. erectum (Red Trillium). Rich woodlands, frequent: w. Ridge; e. line.

T. grandiflorum (White Trillium). Frequent on the wooded hills.

T. undulatum (Painted Trillium). Damp and dry woods, frequent: around Mud P.; s. e. slope, and elsewhere.

Smilax herbacea (Carrion Flower). Rich woods, scarce: n. of Mud P.; around Grass B. 3.

Smilax hispida (Bristly Green Brier). Low woods, rare: n. e. and n. w. of Mud P.; n. w. corner.

### *Family Iridaceae (Iris Family)*

Iris versicolor (Blue Flag). Marshes, frequent.

[Sisyrinchium (Blue-eyed Grass). Representatives of this genus should be found in grassland in the preserve.]

### *Family Orchidaceae (Orchid Family)*

[Cyripedium parviflorum, var. pubescens (Larger Yellow Lady's Slipper). Calcareous springy bogs, rare: Beav. Br.; bog s. w. of Shack.]

[C. reginae (Showy Lady's Slipper). Calcareous springy bogs, rare: bog s. w. of Shack.]

C. acaule (Stemless Lady's Slipper). Coniferous woods, scarce: near Grass B. 3; along e. line.

Orchis spectabilis (Showy Orchis). Dich woodlands, rare: near e. line.

Habenaria hyperborea (Green Bog Orchis). Calcareous springy places, scarce: bog s. w. of Shack; near Mud P., and probably elsewhere.

[H. dilatata (White Bog Orchis). Calcareous springy places, rare: bog s. w. of Shack.]

H. psycodes (Smaller Purple Fringed Orchis). Swamps, scarce: stations not listed.

H. fimbriata (Larger Purple Fringed Orchis). Swamps, scarce: stations not listed.

Pogonia ophioglossoides (Pogonia). "Round Marshes" (Dudley).

Calopogon pulchellus (Calopogon). Boggy places, rare: moor of Mud P.

Spiranthes lucida (Early Lady's Tresses). Calcareous runs, rare: n. and e. of Mud P.

[S. cernua (Late Lady's Tresses). Springy places, scarce: south of s. line.]

Epipactis repens, var. ophioides (Smaller Rattlesnake Plantain). Woods: "Round Marshes" (W. W. Rowlee); along e. line.

Liparis Loeselii. Damp mossy places, rare: around Grass B. 3.

## Class Dicotyleloneae

### *Family Salicaceae (Willow Family)*

Populus candicans (Balm-of-Gilead). S. e. of Grass B. 2. The present grove was noted by Dudley who said: "From their relative position it is altogether probable that they were planted next to an old ditch made many years since. But this is only evident after close inspection, as considerable undergrowth at present surrounds them. The trees are all pistillate. Young trees near, have probably sprung up from windfall twigs."

P. tremuloides (Trembling Aspen). Dry woods, frequent.

P. grandidentata (Large-toothed Aspen). Dry woods, less frequent: common near Argus Br.

Salix nigra (Black Willow). Low ground, scarce: near Bog A.

S. lucida (Glossy Willow). Boggy soil, scarce: Bog A; e. line; s. of Hem. Ridge.

S. serissima (Autumn Willow). Calcareous bogs, rare: Grass B. 3; Bog C. Flowering several weeks after other willows and fruiting in late summer. Rare in the Cayuga Lake Basin.

S. Bebbiana (S. rostrata). Swamps, frequent: near Mud P.; near Grass B. 3, and elsewhere.

S. cordata (Heart-leaved Willow). Low ground, frequent.

S. sericea (Silky Willow). Around bogs, frequent: Mud P.; e. line, and elsewhere.

S. discolor (Pussy Willow). Low ground, infrequent: Mud P.; Bog B, and elsewhere.

### *Family Juglandaceae (Walnut Family)*

Juglans cinerea (Butternut). Woodlands and banks, rare: one tree on bank between Bog A and Argus Br.

Carya cordiformis (Bitternut). Woods, scarce: n. and e. of Mud P.; pasture e. of preserve.

*Family Betulaceae (Birch Family)*

Corylus rostrata (Beaked Hazelnut). Dry banks, scarce: ridge w. of Bog A; s. line.

Ostrya virginiana (Ironwood). Woodlands, rare: along e. fence.

Carpinus caroliniana (Blue Beech). Low woods, scarce: Sphaer. Br., and elsewhere.

Betula lenta (Black Birch). Woods, rare: Obsv. Hill.

Betula lutea (Yellow Birch). Woods, very common. Probably both the typical form and var. macrolepis occur.

*Family Fagaceae (Beech Family)*

Fagus grandiflora (Beech). Woods, common.

Quercus macrocarpa (Bur Oak). Low ground, rare: several large trees in n. w. corner.

Q. bicolor (Swamp White Oak). Low ground, rare: n. w. corner; ridge s. e. of Argus Br. At the former station is one tree only. This is over one foot in diameter. Several small trees occur at the second station.

Q. alba (White Oak). Upland woods, rare: one tree on ridge s. e. of Argus Br.

*Family Urticaceae (Nettle Family)*

Ulmus americana (American Elm). Woodlands, frequent.

U. racemosa (Corky-bark Elm). Low woodlands, scarce: upper Beav. Br.; s. line; e. of Grass B. 2.

Humulus Lupulus (Hop). Low thickets, rare: s. e. Mud P.

Laportea canadensis (Wood Nettle). Bog borders, scarce: Bog C; e. line.

Urtica gracilis (Common Nettle). Low rich soil, scarce: s. w. Mud P.

Pilea pumila (Clear Weed). Damp woodlands, scarce; e. line.

Boehmeria cylindrica. Swamps: upper Beav. Br.; Mud P. The var. Drummondiana has not been noted, but probably occurs in the preserve.

*Family Aristolochiaceae (Birthwort Family)*

Asarum canadense (Wild Ginger). Rich wooded banks, scarce: n. of Mud P.; n. e. Grass B. 3.

*Family Polygonaceae (Buckwheat Family)*

Rumex Britannica (Great Water Dock). Swamps, scarce: Bog C; along e. line.

R. crispus (Yellow Dock). Open or waste ground, scarce: s. of Mud P.

R. obtusifolius (Broad-leaved Dock). Open or waste ground, scarce: s. of Mud P.; e. line fence.

R. Acetosella (Sheep Sorrel). Grassland and woods, occasional: Mud P.

Polygonum aviculare (Knot Weed). Open places, scarce.

P. amphibium, f. Hartwrightii (Water Smartweed). Calcareous moors, scarce: Mud P. Forma terestris also occurs in the same locality.

P. Hydropiper (Smartweed). Swales and damp paths, scarce: Mud P.; Sphaer. Br.

[P. acre (Slender Smartweed). Should be found here.]

P. sagittatum (Tear-thumb). Low thickets, scarce: near Mud P.

P. arifolium (Broad-leaved Tear-thumb). Swampy woods, scarce: n. e. Mud P.

### *Family Chenopodiaceae (Goosefoot Family)*

Chenopodium album (Pigweed). Waste places, frequent.

### *Family Phytolaccaceae (Pokeweed Family)*

Phylolacca americana (Pokeweed). Dry ridges: common on Hem. Ridge.

### *Family Caryophyllaceae (Pink Family)*

Arenaria lateriflora (Broad-leaved Sandwort). Calcareous boggy soil, scarce: moor of Mud P.; Grass B. 3; swale, e. line.

A. serpyllifolia (Thyme-leaved Sandwort). Weedy places, occasional.

Stellaria borealis (Northern Chickweed). Calcareous boggy places, rare: moore of Mud P.

S. longifolia (Long-leaved Chickweed). Damp open thickets, scarce: around Mud P.

S. media (Common Chickweed). Open places along paths, occasional.

Cerastium vulgatum (Mouse-ear Chickweed). A weed in woods, scarce: around Mud P.

Silene noctiflora (Night-flowering Catchfly). Dry thickets, scarce: Mud P.

Saponaria officinalis (Bouncing Bet). Weedy places, occasional.

### *Family Portulaceae (Purslane Family)*

Claytonia caroliniana (Broad-leaved Spring Beauty). Rich woods, frequent: West Ridge.

### *Family Ceratophyllaceae (Hornwort Family)*

Ceratophyllum demersum (Hornwort). In Mud P.

*Family Ranunculaceae (Crowfoot Family)*

Aquilegia canadensis (Wild Columbine). Dry wooded bank, locally frequent: West Ridge.

Actaea alba (White Baneberry). Dry rich woods, infrequent: around Mud P.; e. line; probably elsewhere. Forma rubrocarpa, with red berries, occurs along e. line.

A. rubra (Red Baneberry). Similar localities, scarce: s. e. Grass B. 2.

Trollius laxus (Globe Flower). Marl springs and meadows: upper Beav. Br.

Coptis trifolia (Gold Thread). Rather damp, chiefly coniferous woods, frequent.

Caltha palustris (Marsh Marigold). Swales, frequent.

Ranunculus aquatilis, var. capillaceus (White Water Buttercup). Floating in Beav. Br.

R. abortivus (Small Flowered Buttercup). Dry woods, frequent: around Mud P.

R. recurvatus (Buttercup). Dry or low woods, frequent: around Mud P.; e. line.

R. septentrionalis (Marsh Buttercup). Swampy woods, frequent: around Mud P., and elsewhere.

R. acris (Common Field Buttercup). Rich damp or dry open places, frequent.

Thalictrum dioicum (Spring Meadow-rue). Dry wooded ridges, scarce: s. w. Mud P.; railroad e. of Gracie Station.

T. polygamum (Swamp Meadow-rue). Swamps and marshes, frequent.

Anemone virginiana (Tall Anemone). Dry woods, scarce: s. and s. e. of Mud P.

Hepatica acutiloba (Acute-leaved Hepatica). Dry woods, common.

Clematis virginiana (Common Clematis). Low woods, frequent.

*Family Berberidaceae (Barberry Family)*

Podophyllum peltatum (May Apple, Mandrake). Rich woods and banks, frequent.

Caulophyllum thalictroides (Blue Cohosh). Rich woods, frequent.

*Family Papaveraceae (Poppy Family)*

Sanguinaria canadensis (Bloodroot). Dry woods, scarce: West Ridge.

*Family Fumariaceae (Fumitory Family)*

Dicentra Cucullaria (Dutchman's Breeches). Rich woods, scarce: West Ridge.

D. canadensis (Squirrel Corn). Rich woods, frequent: n. of Mud P.; West Ridge.

### *Family Cruciferae (Mustard Family)*

Capsella Bursa-pastoris (Shephard's Purse). Open weedy places, scarce.

Nasturtium nasturtium-aquaticum (Water Cress). In springs, scarce: pasture and woods, s. Mud P.

Barbarea vulgaris (Barberry). Damp open places, scarce: around Mud P.

Dentaria diphylla (Crinkle-root). Rich woods, frequent.

D. laciniata (Toothwort). Rich woods, scarce: West Ridge. A form answering to D. maxima was found in the same locality.

Cardamine bulbosa (Spring Cress). Swamps, scarce: Grass B. 3.

C. pratensis, var. palustris (Cuckoo Flower). Calcareous marshes, rare: moor of Mud P.

C. pennsylvanica. Swamps, frequent: around Mud P.; n. e. corner, and elsewhere.

### *Family Sarraceniaceae (Pitcher-plant Family)*

Sarracenia purpurea (Pitcher Plant). Acid bogs, scarce: Bogs A and B. Formerly more abundant.

### *Family Droseraceae (Sundew Family)*

Drosera rotundifolia (Round-leaved Sundew). Bogs and rotten logs in calcareous places, occasional: Grass B. 3; moor of Mud P.; upper Beav. Br.

### *Family Saxifragaceae (Saxifrage Family)*

Saxifraga pennsylvanica (Swamp Saxifrage). Boggy woods, frequent: Mud P.; Bog A, and elsewhere.

Tiarella cordifolia (False Miterwort). Dry or damp woods, frequent.

Mitella diphylla (Miterwort). Rich woods, scarce: West Ridge.

M. nuda (Swamp Miterwort). Boggy woods, rare: "Round Marshes" (Dudley); upper Beav. Br.

Chrysosplenium americanum (Golden Saxifrage). Muddy springs and spring streams, scarce: e. line, and elsewhere.

Parnassia caroliniana (Grass of Parnassus). Calcareous bogs, rare: moor of Mud P.; Grass B. 1.

Ribes Cynosbati (Wild Gooseberry). Dry woods and pastures, occasional: Obsv. Hill; e. line.

R. hirtellum (Swamp Gooseberry). Calcareous bogs, scarce: moor of Mud P.; Grass B. 1 and 3; near e. line.

R. americanum (Wild Black Currant). Swampy woods, scarce: base of Obsv. Hill.

R. lacustre (Swamp Black Currant). Swamp near "Round Marshes" (Dudley). Not since seen and probably an error as it has not been found elsewhere in the Cayuga Lake Basin.

R. prostratum (Skunk Currant). Low woods around bogs, frequent.

R. triste, var. albinervium (Swamp Red Currant). Low woods, scarce: around Bog A and Mud P.

*Family Hamamelidaceae (Witch-hazel Family)*

Hamamelis virginiana (Witch Hazel). Upland woods, rare: e. of Grass B. 2.

*Family Rosaceae (Rose Family)*

Spiraea alba (Meadow-sweet). Low grounds, frequent: around Mud P.; n. of bogs toward railroad.

[S. latifolia (Broad-leaved Meadow-sweet). Around Chicago bog.]

Pyrus communis (Common Pear). One small bush, s. w. corner.

Malus pumila (Common apple). Trees s. w. of Mud P.; also w. line.

Sorbus americana (American Mountain Ash). Around bogs, rare: Bogs A and B.

Aronia melanocarpa (Black Chokeberry). Around bogs, common: Bog A. A. arbutifolia has not been found at McLean.

Amelanchier intermedia (Swamp Shadbush). Low shrub border around bogs, frequent: Mud P.; Bogs A and B, and elsewhere.

A. canadensis (Upland Shadbush). Low and upland woods, scarce: Grass B. 3.

A. laevis (Smooth Shadbush). Low and upland woods, occasional: McLean entrance to woods around bogs.

Crataegus monogyna (English Hawthorn). Uplands, scattered plants: edge of Obsv. Hill.

C. punctata (Wild Thorn). Open uplands and along marshes, frequent.

C. macrosperma (Wild Thorn). Woods n. of Mud P., a few plants.

Fragaria virginiana (American Strawberry). Dry woods and banks, frequent.

F. vesca, var. americana. Damp or dry woods, scarce: around Mud P.

Waldsteinia fragarioides (Barren Strawberry). Woods and banks, frequent: Obsv. Hill; around Mud P.; West Ridge, and elsewhere.

Potentilla fruticosa (Shrubby Cinquefoil). "Round Marshes," eastern end (Dudley).

P. palustris (Marsh Cinquefoil). Swales and bog borders, scarce: "Middle Round Marsh," *i. e.,* Bog B. (Dudley); bush swamp, n. e. corner.

P. norvegica, var. hirsuta (Cinquefoil). Upland woods, scarce: s. e. of Mud P.

P. argentea (Silvery Cinquefoil). Open thickets and wood borders, occasional: Obsv. Hill; n. of Mud P. Plants from the latter station may be referred to var. simplex.

Geum canadense (Small White Avens). Low or upland woods, scarce: around Mud P.

G. virginianum (Large White Avens). Low woods, scarce: Bog A and vicinity.

G. strictum (Yellow Avens). Low woods, scarce: s. e. Mud P.

G. rivale (Purple Bog Avens). Boggy soil, frequent: Mud P.; n. line, and probably elsewhere.

Rubus idaeus, var. strigosus (Red Raspberry). Upland wood borders, frequent.

[R. occidentalis (Black Raspberry). Has not been found in the vicinity of preserve.]

R. pubescens (Dwarf Raspberry). Boggy woods, frequent: Grass B. 3, and elsewhere.

R. hispidus (Trailing Blackberry). Low ground around bogs, scarce: e. and s. of Grass B. 2.

R. jacens. Similar situations, scarce: around Mud P. and Bog A.

R. canadensis (Smooth Blackberry). "Border of open bog, Round Marshes" (Herb.); near Grass B. 3.

R. allegheniensis (Common Blackberry). Woods and banks, common. A form answering to R. pergratus is frequent.

[Dalibarda repens. On humus in rich woods; upper Beav. Br.]

Agrimonia gryposepala (Agrimony). Chiefly upland woods, scarce: w. of Mud P.

[A. striata. Should be found here.]

[Sanguisorba minor (Garden Burnet). Open pasture banks, locally abundant: Upper Beav. Br.]

Rosa palustris (Swamp Rose). Swamps, scarce: Grass B. 1.

Prunus pennsylvanica (Fire or Pin Cherry). Upland woods, frequent.

P. virginiana (Choke Cherry). Woods s. e. of Mud P.

P. serotina (Black Cherry). Upland woods, common on the ridges: around Mud P., and elsewhere.

### *Family Leguminosae (Pea Family)*

Trifolium repens (Creeping White Clover). Grassy openings, scarce: s. e. Mud P.

Trifolium pratense (Red Clover). Grassy openings, scarce.

T. hybridum (Alsike Clover). Grassy openings: s. e. Mud P.

T. agrarium (Yellow Hop Clover). Openings on Obsv. Hill.

Medicago lupulina (Black Medick). Grassy openings, scarce.

Amphicarpa monoica (Hog Peanut). Low thickets, occasional: w. line; Sphaer. Br.

Apios tuberosa (Groundnut). Low thickets, scarce: bush swamp, e. line.

*Family Oxalidaceae (Wood-sorrel Family)*

Oxalis montana (Wood Sorrel). Humus in rich woods, frequent: around Mud P.; s. of Bog A; s. e. slope.

O. europaea (Yellow Wood Sorrel). Woods and borders, scarce: s. e. of Mud P.

O. stricta (Yellow Wood Sorrel). Paths, rare: along Sphaer. Br.

*Family Geraniaceae (Geranium Family)*

Geranium maculatum (Cranesbill). Wood borders, scarce: around Mud P.

G. Robertianum (Herb Robert). Woods and wood borders, occasional: around Mud P.

*Family Polygalaceae (Milkwort Family)*

Polygala sanguinea (Purple Milkwort). "McLean" (Eames).

*Family Limnanthaceae (False Mermaid Family)*

Floerkea proserpinacoides (False Mermaid). Muddy runs in rich soil, but locally abundant: Inlet Br., s. e. Shack.

*Family Anacardiaceae (Cashew Family)*

Rhus typhina (Staghorn Sumach). Dry banks and ridges, frequent: scattered through open places. Many dead colonies overgrown with trees.

R. Vernix (Poison Sumach). Bog borders, scarce: between Bogs A and B; along n. and e. lines.

*Family Aquifoliaceae (Holly Family)*

Ilex verticillata (Winterberry, Black Alder). Bog borders, scarce: Mud P.; Grass B. 3, and elsewhere.

Nemopanthus mucronatus (Mountain Holly). Bog borders, frequent: Bogs A and B.

### *Family Celastraceae (Staff-tree Family)*

Celastrus scandens (American Bittersweet). Ridges, scarce: s. of Mud P.

### *Family Aceraceae (Maple Family)*

Acer rubrum (Red Maple). Swamps, common.

A. saccharum (Sugar Maple). Upland woods, frequent.

A. nigrum (Black Maple). Upland woods, rare: e. line.

A. pennsylvanicum (Striped Maple, Moosewood). Damp woodlands, scarce: s. entrance; along Beav. Br.; Obsv. Hill; s. e. of Bog A.

A. spicatum (Mountain Maple). Woods frequent, or common.

### *Family Balsaminaceae (Touch-me-not Family)*

Impatiens pallida (Pale Touch-me-not, Jewelweed). Rich low woods: common in several places along e. line.

I. biflora (Spotted Touch-me-not, Jewelweed). Rich low woods: common s. and e. lines.

### *Family Rhamnaceae (Buckthorn Family)*

Rhamnus alnifolia (Swamp Buckthorn). Calcareous boggy places, locally common: Mud P.; Grass B. 3.

R. cathartica (Common Buckthorn). Woods, occasional: around Mud P.; Beav. Br.

### *Family Vitaceae (Grape Family)*

Parthenocissus quinquefolia (Virginia Creeper, Woodbine). Damp woodlands, scarce: s. e. of Mud P.

P. vitacea (Virginia Creeper, Woodbine). Similar habitats: woods s. e. of Grass B. 2.

### *Family Tiliaceae (Linden Family)*

Tilia americana (Basswood). Woods, occasional: around Mud P.

### *Family Malvaceae (Mallow Family)*

Malva rotundifolia (Round-leaf Mallow, Cheeses). Damp weedy places, rare. Locality not noted.

### *Family Hypericaceae (St. Johnswort Family)*

Hypericum perforatum (Common St. Johnswort). Dry open places, scarce: s. e. of Mud P.

H. punctatum. Dry or damp thickets, scarce: s. e. of Mud P.; e. line.

H. mutilum (Small St. Johnswort). Muddy shores and swales, scarce: in woods near Sphaer. Br.

H. virginicum (Purple St. Johnswort). Boggy soil, scarce: moor of Mud P.

*Family Violaceae (Violet Family)*

Viola cucullata (Marsh Blue Violet). Low woods and marshes, frequent.

[V. affinis. A form under the balm-of-Gilead colony and elsewhere resembles this species in several characteristics, but differs in others. It should receive further study.]

V. sororia (Common Blue Violet). Ridges and banks in damp or dry soil, frequent.

V. rotundifolia (Stemless Yellow Violet). Rich woods in humus, frequent: West Ridge; Shack; s. e. slope, and elsewhere.

V. Selkirkii (Stemless Spurred Violet). Rich woods, scarce: around Mud P.; Grass B. 2; e. line.

V. pallens (White Violet). Marsh borders, generally in muddy soil, frequent.

V. blanda (White Violet). Rich woods near Mud P.

V. incognita (White Violet). Woods bordering swamps, common. The var. Forbesii has not been reported.

V. renifolia, var. Brainerdi (White Violet). Rich woods, scarce: West Ridge.

V. pubescens (Stemmed Yellow Violet). Woods, rare: alone e. line. Probably this species, but identification not certain.

V. eriocarpa (Stemmed Yellow Violet). Woods, rare: s. e. slope.

V. canadensis. Rich woods, scarce: s. e. slope.

V. striata (Stemmed White Violet). "Woods of Round Marshes" (Dudley).

V. conspersa (Stemmed Purple Violet). Damp woodlands and banks, frequent.

V. rostrata (Long Spurred Violet). Woodlands, occasional: s. e. of Mud P.

*Family Thymelaeaceae (Mezereum Family)*

Dirca palustris (Leatherwood). Rich woodlands, scarce: s. e. slope.

*Family Lythraceae (Loosestrife Family)*

Decodon verticillatus, var. laevigatus (Swamp Loosestrife). Shallow water of pond margins, locally abundant: Mud P.

*Family Onagraceae (Evening Primrose Family)*

Ludvigia palustris (Water Purslane). Muddy places, scarce: near Mud P.

Epilobium angustifolium (Purple Fireweed). Dry woodlands and cleared areas, occasional: w. of Mud P.; near Bog B.

E. hirsutum (Hairy Fireweed). Swale s. e. of Mud P.

[E. molle. Calcareous marshes, scarce: near the "Round Marshes" (Dudley); marsh s. w. of Shack, but outside the preserve.]

E. densum (Willow-herb). Calcareous marshes, scarce: "Round Marshes" (Dudley); moor of Mud P.; Grass B. 3.

E. coloratum (Willow-herb). Swampy ground, scarce: n. of Mud P.

E. glandulosum, var. adenocaulon (Willow-herb). Swamps, scarce: s. e. of Mud P.

[Oenothera perennis (Sundrops). Dry pastures and fields, scarce: hill by Bog C. Outside the preserve.]

Circaea latifolia (Enchanter's Nightshade). Damp rich woodlands, scarce: s. e. of Mud P.

C. alpina (E. Nightshade). Damp rich woodlands, scarce: e. line.

### *Family Araliaceae (Ginseng Family)*

Aralia racemosa (Spikenard). Woodlands, infrequent: near Grass B. 3; West Ridge; s. e. slope.

Aralia hispida (Bristly Sarsaparilla). Dry thickets, scarce: Obsv. Hill; e. of Bog C.

A. nudicaulis (Wild Sarsaparilla). Woodlands, scarce: s. of Mud P.; Obsv. Hill.

### *Family Umbelliferae (Parsley Family)*

Sanicula marilandica (Sanicle Snakeroot). Rich woods, scarce: around Mud P.

Hydrocotyle americana (Pennywort). Low ground, frequent: moor of Mud P.; s. of Bog A; Grass Bog 3, and elsewhere.

Osmorhiza Claytoni (Sweet Cicily). Woods, infrequent: Hem. Ridge; s. e. slope.

Cicuta maculata (Water Hemlock). Bog borders, scarce: Grass B. 3.

C. bulbifera (Bulb-bearing Water Hemlock). Swales and bog borders, scarce: near Grass B. 3; n. e. corner.

[Sium suave (Water Parsnip). Chicago Bog.]

Cryptotaenia canadensis (Honewort). Damp woods, scarce: n. of Mud P.; Sphaer. Br.

Zizia aurea (Golden Alexanders). Damp woods, scarce: around Mud P.

Pastinaca sativa (Parsnip). Waste ground; station not recorded.

Conioselinum chinense (Hemlock Parsley). Swamps, occasional: "Round Marshes" (Dudley); near Grass B. 3; probably elsewhere.

Angelica atropurpurea (Angelica). Swamps and marshes, occasional: e. line; near Bog B; Beav. Br.

Daucus Carota (Carrot). Waste ground, scarce: several places.

### *Family Cornaceae (Dogwood Family)*

[Cornus canadensis (Bunch-berry). Banks: upper Beav. Br.]

Cornus Amomum (Kinnikinnik). Swampy thickets, frequent: Mud P., and elsewhere.

C. stolonifera (Red-osier Dogwood). Swamps, common.

C. candidissima (Gray Dogwood). Ridges and bog borders, common.

C. alternifolia (Alternate-leaved Dogwood). Woods, scarce: Mud P.; Bogs A and B.

### *Family Ericaceae (Heath Family)*

Monotropa uniflora (Indian Pipe). Rich woods, occasional: n. w. corner; e. of Bog B, and elsewhere. A saprophyte, devoid of chlorophyll.

Pyrola elliptica (Shin-leaf). Woods, frequent: Obsv. Hill; around Mud P.

Chamaedaphne calyculata (Leather Leaf). On the moors of acid peat bogs, and on bog borders, locally abundant: Bogs A, B and C.

Andromeda glaucophylla (Bog Rosemary). Situations similar to the last, frequent: Bogs A and B.

Gaultheria procumbens (Wintergreen). Woods, especially near conifers, frequent.

[Chiogenes hispidula (Creeping Snowberry). Not reported, but should be found here.]

Vaccinium canadense (Velvet-leaf Blueberry, Sour-top). Acid bogs, locally abundant: Bogs A and B.

V. corymbosum (High Blueberry). Bogs and bog margins, common. Characteristic of acid bogs, but found sparingly in calcareous situations. Var. glabrum is equally abundant. Var. amoenum has not yet been reported from the preserve.

Vaccinium oxycoccus (Smaller Cranberry). Acid moors, locally abundant: Bogs A and B.

V. macrocarpon (Large Cranberry). Bog moors, scarce: Mud P.; also in bog s. of Shack. Ordinarily a plant of acid bogs, but here found only in calcareous moors.

### *Family Primulaceae (Primrose Family)*

Lysimachia terrestris (Yellow Loosestrife). Bog borders (calcareous?), scarce: Bog C.

L. producta. Border of Bog C. This has often been considered a hybrid of

L. terrestris with L. quadrifolia, but the latter species has not been reported from McLean. It is probably an extreme form of L. terrestris.

L. thyrsiflora (Tufted Loosestrife). Calcareous bogs, scarce: "Round Marsh" (Dudley); Mud P.

Steironema ciliatum (Fringed Loosestrife). Swamps and swamp borders, frequent: near Mud P.; Grass B. 3; n. e. corner, and elsewhere.

Trientalis borealis (Star Flower). Woods, frequent: s. e. slope; near Bog A., and elsewhere.

### *Family Oleaceae (Olive Family)*

Fraxinus americana (White Ash). Upland woods, frequent.

F. nigra (Black Ash). Swamps, occasional: between Bogs A and B; e. line.

### *Family Gentianaceae (Gentian Family)*

Menyanthes trifoliata (Buckbean). Calcareous bogs, local: n. side Mud P.

### *Family Asclepiadaceae (Milkweed Family)*

Asclepias syriaca (Common Milkweed). Open places; stations not recorded.

A. incarnata (Swamp Milkweed). Edge of grass bogs, common.

### *Family Convolvulaceae (Morning-glory Family)*

Convolvulus sepium (Hedge Bindweed, Wild Morning-glory). Found here, but station not recorded.

### *Family Hydrophyllaceae (Waterleaf Family)*

Hydrophyllum virginianum (Waterleaf). Rich low woods, scarce: around Mud P.; s. e. slope.

H. canadense (Waterleaf). Rich woods, rare: along e. line.

### *Family Boraginaceae (Borage Family)*

[Cynoglossum officinale (Hound's Tongue). Should occur in pastures around the bogs.]

Hakelia virginiana (Beggar's Lice). Openings in woods, scarce: s. e. of Mud P.

[Myosotis scorpioides (Forget-me-not). Occurs in swamps near the bogs, but has not yet been found within the limits of the preserve.]

*Family Verbenaceae (Vervain Family)*

Verbena urticifolia (White Vervain). Marshes, scarce: several places about the preserve.

V. hastata (Blue Vervain). Marshes, frequent. Also pink form near Bog B.

*Family Labiatae (Mint Family)*

Scutellaria lateriflora (Skullcap). Low ground, scarce: along Sphaer. Br.

S. epilobifolia (Showy Skullcap). Marshes, frequent: Bog C; Mud P.; probably elsewhere.

Nepeta Cataria (Catnip). Open places, rare: e. fence.

N. hederacea (Ground Ivy, Gill). Paths in woods, occasional.

Prunella vulgaris (Self-heal). Open woods, scarce: s. e. Mud P.

Galeopsis Tetrahit, var. bifida (Hemp-nettle). Springy place in woods; near e. line.

Leonurus Cardiaca (Motherwort). Open places, occasional; stations not listed.

Monarda didyma (Oswego Tea, Bee Balm). Low woods, occasional: around Mud P.

Hedeoma pulegioides (American Pennyroyal). Open places, scarce: path, base of West Ridge, and elsewhere.

Satureja vulgaris (Basil). Woods and open places, scarce: near Mud P.; s. e. slope.

Lycopus uniflorus (Water Horehound). Low ground, scarce: near s. w. corner.

L. americanus (Water Horehound). Swamps, scarce: around Mud P., and elsewhere.

Mentha spicata (Spearmint). Low ground: Inlet Br.

M. arvensis, var. canadensis (Wild Mint). Swamps and marshes, scarce: near Mud P.

Collinsonia canadensis (Horse Balm, Rich-weed). Rich woods, rare: w. of Mud P.

*Family Solanaceae (Nightshade Family)*

Solanum Dulcamara (Blue Nightshade, European Bittersweet). Low thickets, frequent.

*Family Scrophulariaceae (Figwort Family)*

Verbascum Thapsus (Common Mullein). Dry woods and openings, scarce: s. e. of Mud P.

V. Blattaria (Moth Mullein). Open places; stations not recorded.

Linaria vulgaris (Yellow Toadflax, Butter-and-eggs). Openings in woods, scarce: s. e. of Mud P.

Pentstemon laevigatus, var. Digitalis (Beard-tongue). Dry openings, rare: Obsv. Hill.

Chelone glabra (Turtle-head). Swamps and marshes, occasional: Mud P., and elsewhere.

Mimulus ringens (Monkey Flower). Marshes, scarce: near n. e. corner.

Gratiola neglecta (Hedge Hyssop). Muddy places, scarce: near Hem. Ridge; w. of Mud P.

Veronica americana (American Brooklime). Swales and low woods, frequent.

[V. scutellata (Marsh Speedwell). Chicago Bog and vicinity.]

V. officinalis (Common Speedwell). Dry open woods, occasional: near Mud P., and elsewhere.

V. serpyllifolia (Thyme-leaved Speedwell). Open places, occasional: Obsv. Hill; around Mud P.

V. arvensis (Corn Speedwell). Open places, rare: near Hem. Ridge.

Pedicularis canadensis (Lousewort, Wood Betony). Wooded bank near Sphaer. Br. Rare in the McLean region.

### *Family Orobanchaceae (Broom-rape Family)*

Epifagus virginiana (Beech-drops). Beech woods, frequent. Parasitic on the roots of beech and lacking in green color.

Orobanche uniflora (One-flowered Cancer-root). Low woods, scarce: n. of Mud P. Parasitic on roots and without green color.

### *Family Plantaginaceae (Plaintain Family)*

Plantago major (Common Plantain). Weedy places, rare: near s. entrance.

P. lanceolata (Rib-grass, English Plantain). Open places, scarce.

### *Family Rubiaceae (Madder Family)*

Galium aparine (Cleavers, Goose Grass). Low thickets, scarce: around Mud P.; n. e. corner.

G. lanceolatum (Wild Liquorice). Woods, scarce: West Ridge.

G. labradoricum. Calcareous bogs, locally frequent: Mud P.

G. Claytoni (Bedstraw). Boggy places, scarce: Bog C.

G. trifidum (Bedstraw). Bogs, scarce: moor of Mud P.

G. asprellum (Rough Bedstraw). Swamps, occasional: near Mud P., and elsewhere.

G. triflorum (Sweet-scented Bedstraw). Woods, frequent.

Mitchella repens (Partridge Berry). Woods, especially near hemlocks, frequent: s. and e. of Mud P., and elsewhere.

*Family Caprifoliaceae (Honeysuckle Family)*

Diervilla Lonicera (Bush Honeysuckle). Dry ridges, scarce: around Bog A.

Lonicera canadensis (American Fly Honeysuckle). Damp woodlands, frequent: Obsv. Hill; Sphaer. Br.; Grass B. 3.

Triosteum perfoliatum, var. aurantiacum (Horse Gentian). Damp thickets, scarce: path n. of Mud P.; e. line.

Viburnum alnifolium (Hobble-bush). Woods, frequent: around Grass B. 3; around Bog A, and elsewhere.

Viburnum Opulus, var. americana (High-bush Cranberry). Open swamps in calcareous soils, scarce: Inlet Br. (e. of elm tree, big colony); Grass B. 3; upper Beav. Br.

V. acerifolium (Maple-leaved Arrow-wood). Woods, occasional: near Grass B. 3; near Mud P.

V. dentatum (Arrow-wood). Bog borders, scarce: Mud P.; Bog A; probably elsewhere.

V. cassinoides (Withe-rod). Bog borders, frequent: "Round Marshes" (Dudley); common around Bogs A and B.

V. Lentago (Sheepberry). Low woods and thickets, scarce: s. w. of Mud P.

Sambucus racemosa (Red-berried Elder). Woods, frequent: Obsv. Hill; West Ridge, and elsewhere.

S. canadensis (Common Elder). Low woods, scarce: around Mud P.; around Bog A.

*Family Dipsacaceae (Teasel Family)*

Dipsacus sylvestris (Common Teasel). Low woods, scarce: near Hem. Ridge.

*Family Campanulaceae (Bluebell Family)*

Campanula uliginosa (Marsh Bell-flower). Calcareous meadows, locally frequent: moor of Mud P.

*Family Lobeliaceae (Lobelia Family)*

Lobelia cardinalis (Cardinal Flower). Swales and low thickets, scarce: e. line.

L. siphilitica (Great Lobelia). Low ground, scarce: along stream, e. line; n. e. corner.

Lobelia inflata (Indian Tobacco). Dry open places, frequent.

*Family Compositae (Composite Family)*

Eupatorium maculatum (Joe-Pye Weed). Marshes, frequent.

E. perfoliatum (Boneset). Low ground, scarce: around Mud P.; near Obsv. Hill, and elsewhere.

E. urticaefolium (White Snakeroot). Dry or damp woods, scarce: e. line; s. of Mud P.

Solidago caesia (Goldenrod). Dry woods, scarce: around Mud P.

S. latifolia (Broad-leaved Goldenrod). Dry woods, scarce and local: n. line.

S. humilis (Bog Goldenrod). Calcareous meadows, rare: "Round Marshes" (Dudley); not since seen.

S. uniligulata, var. neglecta (Bog Goldenrod). Calcareous meadows: "Round Marshes" (Dudley); e. of Mud P., and in Grass B. 3. The typical form of this species occurs in bog s. w. of Shack outside of preserve.

S. arguta (Field Goldenrod). Dry woods, scarce and local: West Ridge.

S. patula (Rough Goldenrod). Calcareous springy places, scarce: n. of Sphaer. Br.; e. line.

S. rugosa (Rugose Goldenrod). Low open ground, common.

S. serotina (Late Goldenrod). Low open ground, occasional: near Mud P.; near Obsv. Hill.

S. altissima (Tall Goldenrod). Low ground, occasional: path n. side Mud P.; n. line.

S. canadensis, var. Hargeri (Canada Goldenrod). Low thickets, occasional.

S. graminifolia (Corymbose Goldenrod). Open places: Obsv. Hill.

Aster divaricatus (Woodland White Aster). Dry woods, s. and e. of Mud P.

A. cordifolius (Heart-leaved Aster). Dry bank along Sphaer. Br.

A. novae-angliae (New England Aster). Low open ground, scarce: s. w. of Mud P.

A. puniceus (Tall Blue Aster). Low open ground, occasional: around Mud P.

[A. prenanthoides (Blue Aster). Should be found within the preserve.]

A. junceus (Bog Blue Aster). Calcareous meadows, locally frequent: moor of Mud P.; Grass Bog 3.

A. lateriflorus (Small-flowered White Aster). Low ground, frequent: s. and e. of Mud P.; Sphaer. Br.

A. umbellatus (Tall Swamp White Aster). Low open ground; frequent: Mud P., and elsewhere.

A. acuminatus (Northern Woodland Aster). Dry woods, frequent.

Erigeron philadelphicus (Pink Fleabane). Damp open woods and thickets, occasional: around Mud P.

E. annuus (Daisy Fleabane, White-weed). Open places, occasional: Mud P.

E. canadensis (Horse-weed). Open places, scarce: near Shack entrance.

[Antennaria neglecta (Pussy's Toes). Grassy pasture: s. of s. line fence.]

[A. neodioica (Pussy's Toes). S. of s. line fence.]

[A. plantaginifolia (Pussy's Toes). S. of s. line fence.]

Anaphalis margaritacea (Pearly Everlasting). Dry open places, occasional: e. of Mud P., and elsewhere.

Gnaphalium decurrens (Sticky Everlasting). Dry ridges, scarce: Hem. Ridge; Obsv. Hill; around Bog C.

Inula Helenium (Elecampane). Damp open soil, occasional: near Mud P.; e. line.

Ambrosia artemisiifolia (Ragweed). Open places, common.

Rudbeckia laciniata (Cone-flower). Low woods, occasional: around Mud P.; w. line.

Bidens cernua (Marsh Marigold). Low ground, scarce: around Mud P.

Helenium autumnale (Sneeze-weed). Low ground, scarce; no stations recorded.

Achillea millefolium (Yarrow). Open places, occasional.

Anthemis Cotula (May-weed). In pasture near s. entrance.

Chrysanthemum Leucanthemum, var. pinnatifidum (White Daisy). Open places, occasional.

Tussilago Farfara (Coltsfoot). Open places, occasional: s. and e. of Mud P.; Sphaer. Br.

Erechtites hieracifolia (Fireweed). Dry open places, scarce: Hem. Ridge.

Senecio aureus (Golden Ragwort). Open calcareous marshes, scarce: around Mud P.; s. w. of Shack in pasture.

Arctium minus (Smaller Burdock). Openings in woods, scarce: Mud P.; e. fence.

Cirsium lanceolatum (Bull Thistle). Openings in woods, scarce: s. e. Mud P.; Hem. Ridge.

C. arvense (Canada Thistle). Openings in woods: s. e. of Mud P.

C. muticum (Swamp Thistle). Edge of bogs and brooks, occasional: Grass B. 3; Sphaer. Br., and elsewhere.

C. pumilum (Pasture Thistle). Open places and pastures, rare: open place along n. line.

Centaurea maculosa (Star Thistle). Dry pasture s. of Shack.

Cichorium Intybus (Chicory). Open places, rare.

Chondrilla juncea (Skeleton-weed). Dry pasture s. of Shack. One plant has persisted for several years. This is the only known plant in central New York.

Taraxacum officinale (Dandelion). Grassy places, frequent.

Lactuca spicata (Blue Lettuce). Low woods, scarce: s. e. of Mud P.

Prenanthes altissima (Rattlesnake-root). Woods, scarce: West Ridge.

Hieracium aurantiacum (Orange Hawkweed, Devil's Paintbrush). Open places, frequent.

H. pratense (Yellow Hawkweed, Yellow Paintbrush). Open places: n. of Mud P. One plant only.

H. paniculata (Slender Hawkweed). Woods, rare: e. line.

[H. scabrum (Rough Hawkweed). May be found here.]

# BRYOPHYTA

By A. LeRoy Andrews

The Beaver Creek region as a whole is rich in bryophytes, hardly less so than the gorges about Cayuga Lake, but many of its species fail to appear in Mud Pond Basin. On the other hand, the latter contains some species which have not been found otherwise in the region of Beaver Creek or in fact elsewhere in the upper Cayuga Lake Basin. These are practically without exception peat-bog species, which are more or less characteristic of northern bogs, but here represent an isolated station on the extreme southern limit of their range. The Reservation may save these to our flora.

As the grass bog is inimical to the growth of bryophytes and the bush-swamp and drier woods are habitats common with us and showing little of special interest in their bryophytes, I shall in the way of introduction to the general list say only a word or two about the Sphagnum bogs, including the shores of Mud Pond itself. In the first place as to Sphagnum species, which are of peculiar interest as giving a name to the type of bog and contributing so much to the life conditions which make the region what it is as to flora and fauna. Their distribution within the area of the Reservation is very irregular. About the shores of Mud Pond occurs a single species—S. capillaceum var. tenellum. The floor of Bog B is entirely carpeted with S. recurvum var. tenue interspersed with S. magellanicum. In the more elevated border of Bog B appear already S. palustre and S. Girgensohnii with S. capillaceum var. tenellum. Bog A shows on the other hand an astonishing wealth of species, not duplicated in any other bog of our vicinity. In the wetter part grows S. Dusenii in its most southerly American station except one similarly isolated in northwestern Connecticut. The only other New York station south of the Adirondacks is that at Sand Lake, near Albany, where it was found long ago by Peck. Other species of the wetter part of the bog are S. papillosum and S. cuspidatum, neither known elsewhere from Tompkins County. Other species of the brushless area of the bog are S. magellanicum, S. recurvum, S. fuscum and S. capillaceum var. tenellum. In the border parts, more or less overgrown with brush, and in the area between Bogs A and B are to be added S. palustre, S. Warnstorfii, S. Girgensohnii and S. fimbriatum. S. Warnstorfii and S. fimbriatum are not known with certainty from other localities in the upper Cayuga Lake Basin. It may be of interest to add that the only species of Sphagnum of our immediate vicinity not found in the Mud Pond bogs are S. compactum and S. subsecundum of the South Hill Marsh and S. squarrosum found in a swamp in Richford.

The other bryophytes of especial interest occur mostly about Mud Pond. Bog A contains the hepatics Mylia anomala and Cephalozia fluitans, not definitely credited to other stations within our environs. Southwest of Mud Pond I have in earlier years found Camptothecium trichoides, another remarkable southern

occurrence. In its limited area it was being encroached upon by grass and brush so that in the summer of 1924 I was quite unable to find it again, though it has perhaps not yet disappeared entirely. Fortunately there is a better station for it further up Beaver Creek. Another case of a surprising record for a northern species is that of Meesea triquetra, which was not noticed before 1924, and was then thriving, though not fruiting, on bare wet peat, for example by the path leading down to the pond. Other noteworthy species of the same region south of the pond are Helodium lanatum and Drepanocladus vernicosus.

The list follows with the habitat of each species.

## Class I. Hepaticae

### *Marchantiales*

Conocephalum conicum. Wet ground in woods.
Marchantia polymorpha. Wet ground near Mud Pond.

### *Jungermanniales*

Jungermannia autumnalis. On rotten wood.
Mylia anomala. On bare peat in Bog A.
Lophocolea heterophylla. On rotten wood, bases of trees, etc.
Cephalozia connivens. Higher places in peat, especially about Bogs A and B.
Cephalozia media. On rotten wood.
Cephalozia catenulata. On rotten wood.
Cephalozia fluitans. On bare peat in wetter parts of Bog A.
Cephalozia curvifolia. On rotten wood.
Calypogeia Trichomanis. On wet ground.
Bazzania trilobata. Ground in woods.
Ptilidium ciliare. Decaying logs and stumps. Our form is the one known as P. pulcherrimum, but it is doubtful if they are specifically distinct.
Radula complanata. On stones by brook.
Madotheca platyphylloides (Porella platyphylla). On bark of trees.

## Class II. Sphagna

Sphagnum magellanicum (S. medium). In Bogs A and B.
Sphagnum palustre (S. cymbifolium). About Bogs A and B.
Sphagnum Dusenii. In wetter part of Bog A.
Sphagnum cuspidatum. In wetter part of Bog A.
Sphagnum recurvum. In Bog A.
Sphagnum recurvum var. tenue. A considerably smaller form carpeting Bog B.

Sphagnum fimbriatum. On higher ground among brush between Bogs A and B.

Sphagnum Girgensohnii. On higher ground among brush about Bogs A and B.

Sphagnum Warnstorfii. About Bog A.

Sphagnum fuscum. In Bog A.

Sphagnum capillaceum var. tenellum (S. rubellum). The most generally distributed species. About Mud Pond, in Bog A and about Bogs A and B.

## Class III. Musci

### 1. *Bryales*

#### Fissidentaceae

Fissidens minutulus. On stones.

Fissidens bryoides. On ground, shaded hillside.

Fissidens taxifolius. On ground in woods.

#### Dicranaceae

Dicranella heteromalla. On bare ground in woods.

Dicranum montanum. On bark of trees.

Dicranum fulvum. Both in its normal form on stones and its form known as D. viride on decayed wood.

Dicranum flagellare. On decayed wood, especially about bogs.

Dicranum scoparium. On ground in woods.

Leucobryum glaucum. On ground in woods.

#### Trichostomaceae

Tortella caespitosa. On ground in woods.

#### Bryaceae

Pohlia pulchella. On bare ground in thin woods.

Pohlia nutans. On ground and decayed wood.

Bryum capillare. On ground containing humus.

Rhodobryum roseum. On ground and rotten wood.

#### Mniaceae

Mnium stellare. Ground in woods.

Mnium punctatum var. elatum. Wet swampy ground, for example south of Mud Pond.

Mnium cuspidatum. Ground in woods.

Mnium affine. Ground in woods.

Aulacomniaceae

Aulacomnium palustre. On swampy and boggy ground at various points.
Aulacomnium heterostichum. On ground in woods.

Meeseaceae

Meesea triquetra. On bare peat south of Mud Pond.

Orthotrichaceae

Ulota ulophylla (U. crispa). Bark of trees.

Leucodontaceae

Leucodon brachypus. On bark of tree.

Climaciaceae

Climacium americanum. On wet and shaded ground at various points.

Leskeaceae

Anomodon attenuatus. Ground in woods and bases of trees.
Anomodon apiculatus. Bark of tree.

Thuidiaceae

Thuidium delicatulum. Wet ground in woods, rotten wood, etc.
Helodium lanatum (Thuidium Blandowii). Very wet ground, especially south of Mud Pond.

Amblystegiaceae

Amblystegium serpens. On ground and rotten wood.
Amblystegium irriguum. On wet, swampy ground in woods.
Campylium hispidulum. Ground in woods.
Campylium stellatum. Boggy ground north of Mud Pond.
Drepanocladus vernicosus. Boggy ground south of Mud Pond.
Calliergon cordifolium. Bog B.
Acrocladium cuspidatum. Boggy ground south of Mud Pond.

Brachytheciaceae

Camptothecium trichoides (C. nitens). Boggy ground south of Mud Pond. Represented by specimens in my herbarium collected May 25, 1912.
Brachythecium oxycladon. Ground in woods.
Brachythecium salebrosum. Ground in woods.
Brachythecium Rutabulum. Wet ground in woods.

Brachythecium rivulare. Wet ground in woods.
Brachythecium velutinum. Ground in woods.
Brachythecium populeum. Stones by brook.
Brachythecium plumosum. Stones by brook.
Eurhynichium hians. Ground in woods.
Eurhynchium strigosum. Ground and stones.
Rhynchostegium serrulatum. Ground in woods.

Entodontaceae

Entodon cladorrhizans. Bark of logs, stumps and trees.

Plagiotheciaceae

Plagiothecium denticulatum. Ground in woods.

Sematophyllaceae

Sematophyllum recurvans. Ground and decayed logs in woods.

Hypnaceae

Pylaisia Schimperi. On bark of trees.
Platygyrium repens. Bark of trees, logs and stumps.
Homomallium adnatum. Stones by brook.
Hypnum reptile. On bark of trees.
Hypnum imponens. On decaying wood, especially logs.
Hypnum Patientiae. Wet ground in woods.
Hypnum Haldanianum. On rotten logs, etc.

Hylocomiaceae

Pleurozium Schreberi. Ground about borders of bogs.

2. *Tetraphidales*

Georgia pellucida. On decayed wood.

3. *Polytrichales*

Catharinaea undulata. Ground in woods. In drier places occurs also C. angustata, which is perhaps only a xerophytic form of the other species.
Pogonatum tenue. On bare ground.
Polytrichum ohioense. Ground in woods.
Polytrichum commune. Ground in woods.
Polytrichum strictum. Drier peat, especially in border region of Bog A.
Polytrichum juniperinum. On decayed log in woods.

# FUNGI

COMPILED BY H. M. FITZPATRICK

The following list, containing less than three hundred species, is clearly only a partial enumeration of even the larger and more easily identified forms. It is chiefly a compilation based on the specimens in the herbaria at Cornell University. Many individuals have contributed to the collection of the material over a period of years. During the past two summers a special effort to add to the list has been made.

## PHYCOMYCETES

### *Order Chytridiales*

| | |
|---|---|
| *Synchytrium aureum* | *Senecio aureum and Viola conspersa* |
| *Woroninella aecidioides* | *Amphicarpa monoica* |

### *Order Peronosporales*

| | |
|---|---|
| *Albugo candida* | *Dentaria diphylla* |
| *Albugo tragopogonis* | *Cirsium muticum* |
| *Peronospora corydalis* | *Dicentra canadensis* |
| *Peronospora ficariae* | *Ranunculus abortivus* and *R. acris* |
| *Peronospora halstedi* | *Eupatorium purpurem* |
| *Peronospora parasitica* | *Dentaria laciniata* |
| *Plasmopara gerani* | *Geranium maculatum* |

### *Order Mucorales*

| | |
|---|---|
| *Endogone pisiformis* | leaf mold |

## ASCOMYCETES

### *Order Protodiscales*

| | |
|---|---|
| *Taphrina alni-incanae* | *Alnus incana* |

### *Order Helvellales*

| | |
|---|---|
| *Corynetes atropurpureus* | humus |
| *Geoglossum glabrum* | humus, rotten log and rich wood soil |
| *Geoglossum ophioglossoides* | sphagnum |
| *Geoglossum difforme* | humus |
| *Trichoglossum farlowi* | ground near swamp |
| *Trichoglossum hirsutum* | ground among moss, humus |
| *Gyromitra* sp. | humus |

| | |
|---|---|
| *Morchella spp.* | humus |
| *Leotia lubrica* | ground among moss |
| *Leptopodia arbella* | grass clumps |

*Order Pezizales*

| | |
|---|---|
| *Acetabula sulcata* | ground |
| *Ascobolus stercorarius* | dung |
| *Ascophanus* sp. | dung |
| *Barlaeina miniata* | tufts of *Funaria*, burnt soil |
| *Cenangium balsameum* | *Tsuga canadensis* |
| *Cenangium carpinea* | *Carpinus caroliniana* |
| *Cenangium furfuraceum* | dead branches of *Alnus* |
| *Ciboria* sp. | *Rubus* |
| *Discina ancilis* | soil |
| *Discina leucoxantha* | |
| *Holwaya gigantea* | hemlock log |
| *Haematomyces faginea* | rotten log |
| *Helotium citrinum* | rotten log |
| *Humaria* sp | burnt soil with *Funaria* |
| *Humaria ithacensis* | *Marchantia polymorpha* |
| *Lachnea scutellata* | rotten wood |
| *Lachnea stercorea* | dung |
| *Lamprospora Crec'hqueraultii* | soil |
| *Mollisia* sp. | *Solidago* stems |
| *Mollisia cinerea* | dead sticks |
| *Orbilia caulophylli* | dead stems *Caulophyllum* |
| *Pezicula rhabarbarina* | *Rubus setosus* |
| *Pezicula carpinea* | bark |
| *Peziza fimetaria* | dung |
| *Peziza repanda* | humus |
| *Sclerotinia* sp. | *Alnus incana* |
| *Sclerotinia* sp. | *Rubus* |
| *Sclerotinia* sp. | *Carex diandra* var. *ramosa* |
| *Sclerotinia* sp. | *Pyrus melanocarpa* |
| *Sclerotinia* sp. | last year's petiole *Symplocarpus foetidus* |
| *Sclerotinia amelanchieris* | *Amelanchier laevis* and *A. intermedia* |
| *Sclerotinia bifrons* | *Populus tremuloides* |
| *Sclerotinia heteroica* | *Vaccinium uliginosum* |
| *Sclerotinia polycodii* | *Polycodium stamineum* |
| *Sclerotinia vaccinii-corymbosi* | *Vaccinium corymbosum* |

| | |
|---|---|
| *Tympanis alnea* | *Alnus incana* |
| *Tympanis conspersa* | *Alnus incana* |
| *Propolis faginea* | oak |

*Order Phacidiales*

| | |
|---|---|
| *Rhytisma acerinum* | *Acer spicatum* |
| *Rhytisma andromedae* | *Andromeda polifolia* |
| *Rhytisma punctatum* | *Acer pennsylvanicum* |
| *Rhytisma ilicis-canadensis* | *Ilex verticellata and Nemopanthus mucronata* |

*Order Hysteriales*

| | |
|---|---|
| *Hysterographium mori* | log |
| *Glonium stellatum* | *Juglans nigra* and *Carya alba* |
| *Lophodermium arundinaceum* | *Triticum vulgare* |
| *Lophodermium typhinum* | *Typha latifolia* |
| *Hysterographium variabile* | *Acer saccharum* |
| *Hypoderma commune* | *Solidago serotina* |

*Order Plectascales*

| | |
|---|---|
| *Myriangium duriei* | scale insect on *Crataegus* |
| *Onygena equina* | cow's hoofs and horns |

*Order Perisporiales*

| | |
|---|---|
| *Asterina rubicola* | *Rubus setosus* |
| *Dimerosporium collinsii* | *Amelanchier canadensis* |
| *Erysiphe aggregata* | *Alnus incana* |
| *Erysiphe cichoracearum* | *Aster puniceus, Inula helenium,* and *Scutellaria laterifolia* |
| *Erysiphe communis* | *Ranunculus acris* |
| *Erysiphe galeopsidis* | *Chelone glabra* |
| *Erysiphe polygoni* | *Oenothera biennis, Parnassia caroliana,* and *Thalictrum polygonum* |

*Order Hypocreales*

| | |
|---|---|
| *Acrospermum compressum* | dead stems of *Caltha palustris* |
| *Melanospora parasitica* | *Isaria* |
| *Hypocrea rufa* | log |
| *Cromocrea gelatinosa* | *Fagus grandifolia* |
| *Cordyceps militaris* | insect pupa |

| | |
|---|---|
| *Hypomyces inaequalis* | *Lactarius* and *Russula* |
| *Hypomyces lactifluorum* | *Lactarius* sp. |
| *Nectria episphaeria* | pyrenomycetes |
| *Creonectria purpurea* | *Acer rubrum* |
| *Ophionectria cerea* | *Massaria* canker |
| *Nectria peziza* | log |
| *Cordyceps capitata* | *Elaphomyces granulatus* |

*Order Dothideales*

| | |
|---|---|
| *Dothidella circumvallata* | *Rubus hispidus* |
| *Rhopographus pteridis* | *Pteridis aquilina* |
| *Phyllachora graminis* | *Poa* sp. |

*Order Sphaeriales*

| | |
|---|---|
| *Xylaria polymorpha* | |
| *Xylaria hypoxylon* | |
| *Diaporthe taleola* | *Acer rubra* |
| *Cucurbitaria elongata* | *Robinia pseudacacia* |
| *Diatrype* sp. | *Alnus incana* |
| *Diatrype virescens* | beech |
| *Diatrype stigma* | wood |
| *Guignardia bidwellii* | *Ampelopsis quinquifolia* |
| *Hypoxylon coccineum* | wood |
| *Hypoxolon fuscum* | beech |
| *Leptosphaeria sp.* | *Thalictrum diocium* |
| *Leptosphaeria doliolum* | *Solidago patula* and *Eupatorium purpureum* |
| *Leptosphaeria vagabunda* | *Prunus virginiana* |
| *Leptosphaeria variegata* | *Phytolacca decandra* |
| *Massaria inquinans* | *Acer saccharinum* |
| *Dibotryon morbosa* | *Prunus* sp. |
| *Mycosphaerella asterinoides* | *Dipsacus sylvestris* |
| *Nummularia bulliardi* | log |
| *Physalospora cydoniae* | *Rhus typhina* and *Prunus* sp. |
| *Eutypella longirostris* | *Ulmus americana* |
| *Scoptria* sp. | *Crataegus* |
| *Valsa leucostoma* | *Prunus serotina* |
| *Rosellinia pulveraceae* | wood |
| *Neopeckia coulteri* | *Pinus rigida* |
| *Melanomma pulvis-pyrius* | *Acer saccharum* |
| *Lasiosphaeria mucida* | log |
| *Lasiosphaeria hispida* | log |

| | |
|---|---|
| *Eutypella venusta* | *Robinia pseudoacacia* |
| *Daldinia concentrica* | log |
| *Ustulina vulgaris* | oak |

BASIDIOMYCETES

*Order Ustilaginales*

| | |
|---|---|
| *Cintractia caracis* | *Carex aquatilis* and *C. stricta* |
| *Cintractia junci* | *Juncus dudleyi* and *J. tenuis* |
| *Ustilago avenae* | *Avena sativa* |
| *Ustilago hordei* | *Hordeum sativum* |
| *Ustilago* (?) *osmundae* | *Osmunda regalis* |
| *Ustilago striaeformis* | *Panicum* |
| *Ustilago tulipae* | *Erythronium americanum* |

*Order Uredinales*

| | |
|---|---|
| *Aecidium grossulariae* | *Ribes oxyacanthoides* and *R. rubrum* |
| *Aecidium* sp. | *Rhamnus alnifolia* |
| *Chrysomyxa pyrolii* | *Pyrola americana* |
| *Coleosporium solidaginis* | *Aster junceus* |
| *Gymnoconia interstitialis* | *Rubus* spp. |
| *Gymnosporangium globosum* | *Crataegus punctata* |
| *Kuehneola uredinis* | *Rubus* sp. |
| *Melampsora populina* | *Populus* |
| *Melampsoropsis cassandrae* | *Cassandrae calyculata* |
| *Milesina kriegeriana* | *Aspidium marginale* |
| *Phragmidium potentillae* | *Potentilla* sp. |
| *Phragmidium speciosum* | *Rosa* |
| *Puccinia agropyri* | *Thalictrum polygamum* |
| *Puccinia angustata* | *Scirpus cyperinus, S. eriophrum,* and *S. georgianus* |
| *Puccinia anemones-virginiana* | *Anemone virginiana* |
| *Puccinia anthoxanthi* | *Anthoxanthum odoratum* |
| *Puccinia asteratum* | *Solidago paluta* |
| *Puccinia calthae* | *Caltha palustris* |
| *Puccinia caricis* | *Dulichium spathaceum* |
| *Puccinia caricis-solidaginis* | *Solidago rugosa* and *S. serotina* |
| *Puccinia circaeae* | *Circaea alpina, S. intermedia,* and *S. lutetiana* |
| *Puccinia cirsii-lanceolati* | *Carduus lanceolatus* |
| *Puccinia clematidis* | *Thalictrum dioicum* |
| *Puccinia coronata* | *Rhamnus alnifolia* |

| | |
|---|---|
| *Puccinia eatoniae* | *Ranunculus abortivus* |
| *Puccinia eleocharidis* | *Eleocharis tenuis* and *Eupatorium perfoliatum* |
| *Puccinia eriophyri* | *Senecio aureum* |
| *Puccinia extensicola* | *Solidago rugosa* and *Carex stipata* |
| *Puccinia graminis* | *Festuca elatior* and *Agrostis alba* |
| *Puccinia grossulariae* | *Carex flava, C. gracillima* and *C. trisperma, Ribes hirtellum* and *R. nigrum* |
| *Puccinia heucherae* | *Mitella diphylla* |
| *Puccinia impatientis* | *Impatiens biflora* |
| *Puccinia investita* | *Gnaphalium decurrens* |
| *Puccinia iridis* | *Iris versicolor* |
| *Puccinia lobeliae* | *Lobelia syphilitica* |
| *Puccinia maydis* | *Zea mays* |
| *Puccinia menthae* | *Clinopodium vulgare, Satureja vulgaris, Monarda fistulosa,* and *Calamintha clinopodium* |
| *Puccinia poculiforme* | *Cinnia latifolia* |
| *Puccinia podophylli* | *Podophyllum peltatum* |
| *Puccinia polygoni-amphibii* | *Polygonum hartwrightia* and *P. Muhlenbergii* |
| *Puccinia pringsheimiana* | *Ribes oxyacanthoides* |
| *Puccinia rhamni* | *Avena sativa* |
| *Puccinia saxifragae* | *Saxifraga virginiana* |
| *Puccinia sorghi* | *Zea mays* |
| *Puccinia suaveolens* | *Cirsium arvense* |
| *Puccinia taraxaci* | *Taraxacum officinale* |
| *Puccinia tiarellae* | *Tiarella* sp. |
| *Puccinia urticae* | *Urtica gracilis* |
| *Puccinia veratri* | *Veratrum viride* |
| *Puccinia violae* | *Viola incognita, V. papillinacea,* and *V. striata* |
| *Puccinia waldsteineae* | *Waldsteinia fragarioides* |
| *Pucciniastrum agrimoniae* | *Agrimonia hirsuta* |
| *Pucciniastrum coloratum* | *Epilobium coloratum* |
| *Pucciniastrum pustulatum* | *Epilobium adenocaulon* and *E. molle* |
| *Uredinopsis mirabilis* | *Onocles sensibilis* |
| *Uredo cassandrae* | *Cassandra calyculata* |
| *Uromyces caladii* | *Arisaema triphyllum* |
| *Uromyces hyperici* | *Hypericum mutilum* |
| *Uromyces silphii* | *Juncus tenuis* |

*Order Auriculariales*

| | |
|---|---|
| *Eocronartium muscicola* | *Climacium americanum* |

*Order Dacryomycetales*

| | |
|---|---|
| *Dacryomyces* sp. | hemlock log |
| *Guepinia spathularia* | log |

*Order Tremellales*

| | |
|---|---|
| *Sebacina incrustans* | sticks and fallen debris |

*Order Exobasidiales*

| | |
|---|---|
| *Exobasidium vaccinii* | *Andromeda glaucophylla, A. polifolia,* and *Vaccinium macrocarpon* |

*Order Hymeniales*

*Family Agaricaceae*

| | |
|---|---|
| *Agaricus sylvatica* | ground |
| *Amanita flavorubescens* | ground |
| *Amanita muscaria* | ground |
| *Amanita verna* | ground |
| *Armillaria mellea* | roots of beech |
| *Clitopilus abortivus* | ground |
| *Collybia lilacea* | rotten hemlock |
| *Collybia radicata* | buried wood |
| *Collybia tuberosa* | ground |
| *Collybia velutipes* | dead log |
| *Hygrophorus ferrugineus* | ground |
| *Hypholoma hydrophilum* | very rotten beech log |
| *Hypholoma sublentum* | rotting log |
| *Lentinus lecontei* | wood |
| *Lenzites betulina* | dead birch |
| *Lenzites flaccida* | birch |
| *Lenzites sepiaria* | dead hemlock |
| *Lenzites vialis* | hemlock |
| *Marasmius papillatus* | very rotten wood |
| *Mycena leaiana* | dead beech log |
| *Naucoria* sp. | dung |
| *Omphalia campanella* | stump |
| *Omphalia epichysium* | bark old moss-covered maple log |
| *Panus torulosus* | beech and maple stump |
| *Panaeolus retirigus* | dung |
| *Paxillus involutus* | ground |

| | |
|---|---|
| *Pholiota adiposa* | log |
| *Pleurotus applicatus* | *Alnus* |
| *Pleurotus ostreatus* | wood |
| *Pleurotus serotinus* | wood |
| *Pleurotus sulfuroides* | hemlock log |
| *Pluteus cervinus* | ground |
| *Schizophyllum commune* | wood |
| *Stropharia semiglobata* | dung |
| *Stropharia stercoraria* | dung |
| *Tricholoma variegatum* | rotten heartwood of hemlock, spruce |

*Family Polyporaceae*

| | |
|---|---|
| *Boletinus porosus* | ground |
| *Daedalea unicolor* | dead log |
| *Daedalea confragosa* | *Prunus serotina* |
| *Favolus europeus* | wood |
| *Fomes applanatus* | stump |
| *Fomes fomentarius* | stump |
| *Fomes scutellatus* | *Alnus* |
| *Gloeoporus conchoides* | wood |
| *Merulius lachrymans* | very rotten hemlock, spruce log |
| *Merulius tremellosus* | very rotten stump |
| *Plicatura faginea* | dead stems of *Alnus* |
| *Plicatura nivea* | *Alnus incana* |
| *Polyporus borealis* | hemlock |
| *Tyromyces spraguei* | *T. canadensis* |
| *Polyporus brumalis* | beech limb |
| *Polyporus caesius* | birch log |
| *Polyporus fissus* | beech log |
| *Polyporus gilvus* | tree |
| *Polyporus hirsutulus* | wood |
| *Polyporus pubescens* | *Alnus incana* and *Fagus* |
| *Polyporus radiatus* | dead birch stump |
| *Polyporus tsugae* | wood |
| *Polystictus hirsutus* | stump |
| *Polystictus radiatus* | stump |
| *Polystictus versicolor* | stump |
| *Poria obducens* | cherry limb |
| *Poria obliqua* | *Alnus* |
| *Poria subacida* | *Tsuga canadensis* |
| *Poria vincta* | dead limbs |
| *Porothelium fimbriatum* | *Alnus* and *Quercus* |

*Family Thelephoraceae*

| | |
|---|---|
| *Corticium albulum* | rotten log |
| *Corticium alutaceum* | very rotten hemlock, spruce |
| *Corticium vagum* | *Alnus* |
| *Cyphella fasciculata* | dead *Alnus* |
| *Cyphella fulva* | dead *Alnus* |
| *Grandinia burtii* | log |
| *Hymenochaete agglutinans* | living *Alnus* |
| *Hymenochaete corrugata* | wood |
| *Hymenochaete ferruginea* | wood |
| *Peniophora cinerescens* | bark of decaying basswood log |
| *Cyphella sulphurea* | living *Impatiens* stems |
| *Solenia ochracea* | log |
| *Stereum bicolor* | *Fagus* |
| *Stereum complicatum* | *Quercus* |
| *Stereum hirsutum* | birch |
| *Stereum sanguinolentum* | decayed hemlock |
| *Stereum tuberculosum* | decayed cherry |

*Family Hydnaceae*

| | |
|---|---|
| *Hydnum coralloides* | tree |
| *Hydnum repandum* | ground |
| *Hydnum septentrionale* | base of dead maple |
| *Odontia arguta* | rotten wood |
| *Odontia fusca* | rotting wood |
| *Phlebia merismoides* | decorticated wood of *Fagus ferruginea* |

*Order Lycoperdales*

| | |
|---|---|
| *Geaster* sp. | ground |
| *Lycoperdon pyriforme* | stump |

*Order Plectobasidiales*

| | |
|---|---|
| *Scleroderma aurantium* and | *verrucosum* |

FUNGI IMPERFECTI

*Order Sphaeropsidales*

| | |
|---|---|
| *Diplodina stenospora* | *Acer rubrum* |
| *Leptostromella filicina* | *Osmunda regalis* |
| *Leptothyrium juncinum* | *Juncus* |
| *Phyllosticta platanoides* | *Acer spicatum* |

| | |
|---|---|
| *Phyllosicta sphaeropsidea* | horsechestnut |
| *Phyllosticta* sp. | *Typha latifolia* |
| *Septoria alliorum* | *Allium* |
| *Septoria dentariae* | *Dentaria diphylla* |
| *Septoria lobeliae-syphilitica* | *Lobelia syphilitica* |
| *Septoria spiculosa* | *Symplocarpus foetidus* |
| *Septoria viridi-tingens* | *Allium tricoccum* |
| *Sphaeronema fraxini* | *Fraxinus lanceolata* |
| *Sphaeropsis malorum* | *Malus malus* |
| *Sphaeronema acerinum* | *Acer rubrum* |

*Order Melanconiales*

| | |
|---|---|
| *Colletotrichum violae-tricoloris* | *Viola rotundifolia* |
| *Volutella* sp. | rotten berries *Nemopanthus mucronata* |

*Order Moniliales (Hyphomycetes)*

| | |
|---|---|
| *Botrytis* spp. | *Caulophyllum thalictroides, Erythronium americanum, Memyanthes trifoliata, Mianthemum canadense, Ranunculus abortivus, Rosa, Sanguinaria canadensis,* and *Symplocarpus foetidus* |
| *Bacteridium fulvum* | rotten bark, *Fraxinus* |
| *Isaria arachnophila* | spider |
| *Isaria flabelliformis* | *Xylaria* on wood |
| *Isaria militaris* | pupa insect |
| *Isaria umbrina* | *Hypoxylon coccineum* |
| *Ramularia tulasnae* | *Fragaria* |
| *Tubercularia persicina* | *Caeoma nitens* on *Rubus* |

# MYXOMYCETES

## The Slime Molds

By W. C. Muenscher and F. B. Wann

The following list of Myxomycetes is based almost entirely upon observations and collections made during 1923-1925. During these years collections were made from early spring until late autumn in order to obtain those species which do not seem to be common during summer. The list includes sixty-three species in twenty-six genera and ten families. This constitutes over sixty per cent. of the species reported from the Cayuga Lake Basin (1), (2). The nomenclature used and the arrangement of species and genera in families is essentially that used by Lister (3).

### Subclass I. Exosporeae

*Family 1. Ceratiomyxaceae*

Ceratiomyxa fruiticulosa. Common on decayed logs.

C. porioides. Occasional on decaying wood.

### Subclass II. Endosporeae

*Family 2. Physaraceae*

Badhamia decipiens. On stems of living shrubs near Mud P., rare.

B. rubiginosa. One small gathering on mosses.

Craterium leucocephalum. Frequent on leaves and dead stems.

Diachaea leucopoda. Abundant on leaves and sticks.

D. splendens. A single gathering, on leaves.

Diderma effusum. A single gathering.

Diderma spumarioides. Occasional on living stems of grasses.

D. testaceum. Common on living mosses and herbs, especially in the alder swamps.

Fuligo septica. Frequent on decaying stumps.

Leocarpus fragilis. Occasional; on fallen branches of hemlock.

Physarella oblonga. Occurring in large quantity on the lower surface of an elm log.

Physarum cinereum. A single gathering on dead herbs.

P. connatum. Frequent on the lower side of decaying beech logs.

P. contextum. Infrequent.

P. globuliferum. Frequent on bark of decaying logs.

P. nutans. Frequent on decaying wood.

---

1. Wann, F. B. and Muenscher, W. C. Mycologia *14*: 38-41. 1922.
2. Wann, F. B. and Muenscher, W. C. N. Y. State Mus. Bul. 266:107. 1925.
3. Lister, A. A Monograph of the Mycetozoa. Ed. 2. 1911.

P. pulcherrimum. Occasional on well decayed stumps and logs.

P. pulcripes. One large gathering on a moss-covered, decayed log.

P. sinuosum. Very common on stems of grasses in the grass bogs and alder swamps.

P. variable. A single gathering, on leaves.

P. viride. Very common on wood.

### *Family 3. Didymiaceae*

Didymium clavus. One gathering on dead leaves and stems of herbs.

D. melanospermum. On bark of fallen trees.

D. squamulosum. A single gathering, on herbs.

Mucilago spongiosa. Frequent on stems of living herbs and shrubs; on the drier ridges.

### *Family 4. Stemonitaceae*

Comatricha irregularis. On fallen elm tree near the poplar grove.

C. typhoides. Occasional on decaying wood.

Lamproderma arcyrionema. On decayed wood.

Lamproderma violaceum. Rare on decaying wood.

Stemonitis ferruginea. Common on decaying wood.

S. fusca. Common on fallen tree trunks, especially on beech, elm and aspen.

S. pallida. One gathering on wood.

S. splendens. On hemlock stumps.

### *Family 5. Heterodermaceae*

Cribraria argillacea. Common on decayed wood on ridge north of S. Br.

C. aurantiaca. A single gathering on decayed wood.

C. intricata. Frequent on decayed wood.

C. languescens. Common on decayed wood.

Dictydium cancellatum. Frequent on decayed wood.

Lindbladia effusa. On moss-covered, decayed log in wet woods about Bog B.

### *Family 6. Tubulinaceae*

Tubifera ferruginosa. Frequent on stumps and trunks of coniferous trees.

### *Family 7. Reticulariaceae*

Dictydiaethalium plumbeum. On trunk of fallen basswood tree.

Enteridium Rozeanum. Frequent on decaying logs.

Reticularia Lycoperdon. On bark of yellow birch log near Bog B.

*Family 8. Lycogalaceae*

Lycogala epidendrum. Very common on decaying deciduous wood.

L. flavofuscum. One gathering on living sugar maple tree near entrance by Shack.

*Family 9. Trichiaceae*

Hemitrichia clavata. Very common everywhere, on decaying wood.

H. serpula. Frequent under the bark of stumps and logs.

Hemitrichia vesparium. Common, especially on decaying wood of birch, beech and cherry.

Trichia decipiens. On lower side of beech logs.

T. favoginea. Frequent, usually under the bark of hemlock stumps and logs.

T. persimilis. Frequent on bark of decaying logs.

T. scabra. Common on decaying wood.

T. varia. Very common on decaying wood.

*Family 10. Arcyriaceae*

Arcyria cinerea. Common on decayed wood.

A. denudata. Frequent on decaying wood.

A. ferruginea. A single gathering on wood.

A. incarnata. Frequent on decaying wood.

A. insignis. A single gathering on decaying log.

A. nutans. Frequent on decaying wood.

Perichaena chrysosperma. One gathering, on inner bark of elm log.

P. corticalis. One gathering on bark and wood.

# VERTEBRATES

By Dana J. Leffingwell

The study of the vertebrates of the McLean region has been carried on for many years. Other workers in this field did not make any detailed investigations there, probably because of the distance of the bogs from Ithaca. Both Professor A. H. Wright and Professor A. A. Allen have made frequent trips to this region, and I have been able to incorporate their notes in this paper.

My observations upon the fauna at McLean have continued from October, 1922, until June, 1925, under the direction of Professor A. H. Wright. Until 1924, I had not spent more than a fortnight at the preserve, but during that summer I remained there continuously from the first of June until the middle of August.

I have not limited my studies to the area within the preserve, but have also included Beaver Creek from its mouth to its source, and the Chicago or Atoll bog. At this bog, however, no trapping for mammals was done.

In the annotated lists of the vertebrates of the region, the nomenclature and sequence of species of Jordan and Evermann's Fishes of North and Middle America, 1896-1900; Stejneger and Barbour's Checklist of North American Amphibians and Reptiles, 1923; the American Ornithologists Union Checklist of North American Birds, 1910; and Miller's List of North American Recent Mammals, 1923, have been followed.

For valuable notes, helpful criticism and material assistance, I am indebted to Professors A. H. Wright and A. A. Allen, and to Dr. Francis Harper and Dr. C. K. Sibley. To these gentlemen and to all others who have helped me I wish to express my grateful appreciation.

## Fishes

Ameiurus nebulosus. Bullhead. Not uncommon in Mud Pond.

Catostomus commersonii. White Sucker. Adults were found commonly in Mud Pond, while the young seemed to be restricted to Sphaerium Stream and Beaver Creek.

Semotilus atromaculatus. Horned Dace. Common both in Beaver Creek and Sphaerium Stream.

Notropis heterodon. Varying-toothed Minnow. Reed and Wright (1909) find that this species was taken in 1885 in Beaver Creek by J. H. Comstock and S. E. Meek. I have never collected any of these fish at McLean.

Notropis cornutus. Shiner. Common in Beaver Creek.

Rhinichthys atronasus. Black-nosed Dace. Common in both Beaver Creek and Sphaerium Stream.

Salvelinus fontinalis. Brook Trout. Not uncommon in Beaver Creek and occasional in Sphaerium Stream.

Esox reticulatus. Pickerel. One was observed in Sphaerium Stream and several were seen in Mud Pond. A nineteen-inch Pickerel was caught at the pond in 1924.

Eupomotis gibbosus. Sunfish. A few were seen in the pond.

Micropterus salmoides. Large-mouthed Black Bass. Quite common in Mud Pond, and occasional in Beaver Creek.

Perca flavescens. Yellow Perch. Not uncommon in Mud Pond.

Uranidea gracilis. Miller's Thumb. Common in the headwaters of Beaver Creek, and occasional in Sphaerium Stream and Inlet Brook.

### Amphibia

Triturus viridescens viridescens. Newt. The red land forms were not uncommon in the alders, and adults were occasionally found in Mud Pond.

Ambystoma jeffersonianum. Jefferson's Salamander. Five adults of this salamander were taken in the McLean region, four of them during 1924. I found some larvae in the sheltered pools around Mud Pond which I referred to this species, and Professor Wright has taken newly-hatched larvae in the Atoll bog which he thought belonged to this species.

Ambystoma maculatum. Spotted Salamander. The eggs of this species were found in Mud Pond, and a single adult was taken in the woods.

Hemidactylium scutatum. Four-toed Salamander. Throughout the month of May, the adults were usually found, coiled around their eggs, in Grass Bog 1. A single adult was found by Dr. Babiy in the woods under a stone, previous to the breeding season.

Plethodon cinereus. Red-backed Salamander. This species was found most commonly in the moist woodland. During its breeding season, the adults were found in decaying logs coiled about their eggs.

Gyrinophilus porphyriticus. Purple Salamander. These salamanders were found regularly at Gyrinophilus Springs, one of the sources of Beaver Creek, where it apparently breeds, although no eggs of this species have ever been found there. Larvae, however, are not uncommon.

Eurycea bislineata. Two-lined Salamander. Not uncommon near running water.

Desmognathus fuscus fuscus. Dusky Salamander. The larvae of this species were found quite commonly in the upper reaches of Beaver Creek, and the adults were not uncommon in or near running water.

Desmognathus ochrophaeus ochrophaeus. Mountain Salamander. One adult was found in the woods near Inlet Brook by Professor Wright. It was found under a log but a few inches from the water's edge.

Bufo americanus. Toad. These amphibians were found in nearly every type of habitat at McLean. During May they were found very commonly in and around Mud Pond.

Hyla crucifer. Spring Peeper. The Peepers seemed to be very abundant in the spring, when their peeping was most noticeable, but were seldom seen at other times. Transforming larvae were found in the small pools adjacent to Mud Pond during June.

Hyla versicolor. Tree Toad. The scarcity of records for this species shows that it was far from common at McLean. But two Tree Toads were seen at McLean, one near Mud Pond in 1923, and the other by Bog B in 1924.

Rana catesbeiana. Bull Frog. This species was found only at the Gracie Mill Pond, one of the sources of Beaver Creek.

Rana clamitans. Green Frog. Common in Mud Pond, and not uncommon in the Gracie Pond. One frog was taken near the shallow pool in Bog A in a trap set for meadow mice.

Rana palustris. Pickerel Frog. This species was found to be quite common on the upper reaches of Beaver Creek, but was rather uncommon along Sphaerium Stream. Its eggmasses were found both in Atoll bog and in Mud Pond.

Rana pipiens. Meadow Frog. Found commonly in Gracie Pond, Mud Pond, and the upper portion of Sphaerium Stream, and in the alders bordering Mud Pond.

Rana sylvatica. Wood Frog. These frogs were not uncommon in the woods and alders. Eggmasses of this species were found near the outlet of Mud Pond.

## Reptiles

Diadophis punctatus edwardsii. Ring-necked Snake. One specimen was taken near Atoll bog, and another along the headwaters of Beaver Creek. Unfortunately neither snake was kept, so that proof of the subspecies occurring at McLean is still lacking. According to Stejneger and Barbour, this is the subspecies that should occur throughout this part of New York.

Liopeltis vernalis. Smooth Green Snake. This species is apparently restricted to the sphagnum—heath bogs, as it was never observed elsewhere.

Lampropeltis triangulum triangulum. Milk Snake. Not common, and apparently restricted to the alders.

Natrix sipedon sipedon. Water Snake. One individual was seen in the sedges near Mud Pond. Undoubtedly this species is not uncommon along Beaver Creek.

Storeria occipito-maculata. Red-bellied Snake. This species was observed only along Beaver Creek near the preserve.

Thamnophis sirtalis sirtalis. Garter Snake. Rather numerous, especially on the stony hillsides. It was by far the most common reptile of the preserve.

Chelydra serpentina. Snapping Turtle. A Snapping Turtle was seen both in Sphaerium Stream and in Mud Pond. It is not improbable that it was the same individual which was seen in these two connected bodies of water.

Clemmys insculpta. Wood Turtle. Several of these turtles were seen in the woodlands.

Chrysemys marginata marginata. Western Painted Turtle. Rather common in Mud Pond and around its borders. Fourteen individuals were seen at one time in the shallows at the north end of the pond.

### Birds

Podilymbus podiceps. Pied-billed Grebe. Irregular visitant. One bird was seen on Mud Pond September 16, 1924, and again on November 2nd.

Larus argentatus. Herring Gull. Irregular visitant. Several flocks of Gulls were seen flying over the preserve during the winter of 1923.

Anas platyrhynchos. Mallard. Occasional visitant. Mr. John Greeley saw several Mallards near Mud Pond on April 10, 1923. I have heard ducks there several times, but was unable to distinguish the notes of this species from those of the Black Duck.

Aix sponsa. Wood Duck. Occasional visitant. Dr. J. T. Lloyd has seen this duck at McLean on several occasions.

Marila marila. Scaup Duck. Irregular visitant. On October 27, 1922, a female Scaup was seen on Mud Pond.

Charitonetta albeola. Bufflehead. Irregular visitant. A pair of these ducks were seen on the pond November 2, 1924.

Botaurus lentiginosus. Bittern. Probable summer resident. At least one pair of Bitterns bred in Grass Bog 2 during 1924, as birds were seen going there nearly every day.

Ardea herodias herodias. Great Blue Heron. Summer visitant. Several of these big Herons were seen feeding by Mud Pond, but their nesting sites were not found. In 1916, Professor Allen saw a pair of Herons in the Mud Pond area, but I have never seen more than one at a time.

Butorides virescens virescens. Green Heron. Summer resident. A pair of these Herons nested on the Hook in 1924, but this nest was later broken up. This species was also noted on Beaver Creek and at the Gracie Pond.

Philohela minor. Woodcock. Summer resident. A nest of this species was found in the alders near Sphaerium Stream in 1924. A few days afterwards it was destroyed, probably by vermin, but the bird apparently nested again, as later in the season an adult and four young were often seen along Argus Brook, where they fed upon the tube-making caddis-worm.

Gallinago delicata. Wilson's Snipe. Transient visitant. Dr. J. P. Young found a Snipe in one of the pot-holes north of Observation Hill, and I flushed two birds at the source of Inlet Brook.

Pisobia minutilla. Least Sandpiper. Occasional visitant. Two of these Sandpipers were seen at the inlet of the Gracie Pond in May, 1924. Possibly this species is a regular visitant there.

Totanus flavipes. Yellowlegs. Occasional visitant. Professor Wright has recorded this species from the vicinity of Atoll bog.

Helodromas solitarius solitarius. Solitary Sandpiper. Transient visitant. This species was seen both at Mud Pond and at Atoll bog.

Actitis macularius. Spotted Sandpiper. Summer resident. These Sandpipers were found breeding near Beaver Creek, and late in the season, two birds were seen feeding on the mud flats of Mud Pond.

Oxyechus vociferus. Killdeer. Summer visitant. Several Killdeers fed on the mud flats of the pond during the summer, and probably nested on the higher ground near the preserve.

Bonasa umbellus umbellus. Ruffed Grouse. Permanent resident. Grouse were not uncommon at McLean, as they bred there all three years (1923-1925). Both red-tailed and gray-tailed phases were found here.

Phasianus colchicus torquatus. Ring-necked Pheasant. Permanent resident. Pheasants were fairly common both in the preserve and in the neighboring fields. A nest with seven egg-shells was found in Grass Bog 1, and a nest with eight eggs was discovered on the Hook. Apparently this species does not interfere with the Grouse.

Zenaidura macroura carolinensis. Mourning Dove. Summer resident. Doves were found both on the Hook and by Beaver Creek. The beginnings of a nest, probably of this species, was observed in the woods south of the pond.

Circus hudsonius. Marsh Hawk. Summer resident. A pair of these Hawks were seen in both 1923 and 1924, and in 1925 a nest was found in Bog B. Unfortunately the nest was broken up before the eggs hatched.

Accipiter velox. Sharp-shinned Hawk. Irregular summer resident. A pair nested in a hemlock tree near Argus Brook in 1924, but were not seen in other years.

Buteo lineatus lineatus. Red-shouldered Hawk. Probable summer resident. This species undoubtedly breeds in or near the preserve, as one bird was seen there all summer.

Falco sparverius sparverius. Sparrow Hawk. Summer resident. Professor Allen found young Sparrow Hawks on the wing in 1915, but in later years I have found only migrating individuals.

Pandion haliaëtus carolinensis. Osprey. Irregular visitant. In his notes for June 12, 1916, Professor Allen recorded an Osprey in the Mud Pond area. It is probable that this bird was a migrant, as this species is not known to breed in this part of the Cayuga Basin.

Asio wilsonianus. Long-eared Owl. Occasional winter visitant. A flock of five birds were seen on November 27, 1915, by Professor and Mrs. Allen.

Otus asio asio. Screech Owl. Probable permanent resident. Several of these Owls were heard calling during the summer of 1924.

Bubo virginianus virginianus. Great Horned Owl. Probable permanent resident. Professor Allen found the nest of this species near Beaver Creek, and I have seen it in that vicinity several times. I also heard and saw an Owl near the Shack.

Coccyzus erythrophthalmus. Black-billed Cuckoo. Summer resident. This species seemed to be not uncommon in the wooded portion of the preserve, as well as along Beaver Creek.

Ceryle alcyon. Belted Kingfisher. Summer resident. Kingfishers were seen nearly every day at Mud Pond, and several were noted along Beaver Creek. They probably do not breed within the preserve for lack of suitable nesting sites.

Dryobates villosus villosus. Hairy Woodpecker. Permanent resident. At least one pair of these Woodpeckers bred within the preserve, and individuals were seen there throughout the year.

Dryobates pubescens medianus. Downy Woodpecker. Permanent resident. Several pairs nested in the preserve in 1924.

Sphyrapicus varius varius. Yellow-bellied Sapsucker. Uncommon transient and rare summer resident. Professor Allen found this species breeding at McLean in 1916. I have only observed it during migration.

Melanerpes erthrocephalus. Redheaded Woodpecker. Uncommon summer resident. This species was found nesting near Beaver Creek by Professor Allen. I observed a pair of these birds near Atoll bog in July, 1924.

Colaptes auratus luteus. Flicker. Summer resident. Several pairs of Flickers nested near the Shack in 1924, and another pair were seen by Grass Bog 3.

Antrostomus vociferus vociferus. Whip-poor-will. Irregular visitant. One bird, apparently of this species, was seen flying over Mud Pond on August 9, 1924. I tried to collect it, but was unsuccessful.

Chaetura pelagica. Chimney Swift. Summer resident, though not nesting within the preserve. Although this species may not have bred within the preserve, it was seen there regularly throughout the summer. Swifts were most numerous in the evenings when they congregated over the pond to drink and feed on the numerous insects.

Archilochus colubris. Ruby-throated Hummingbird. Summer resident. Both sexes were observed near Bog A, where it is not unlikely that the nest was. The male fed along Argus Brook on the Columbine nectar.

Tyrannus tyrannus. Kingbird. Summer resident. A pair nested in the alders at the north end of Mud Pond. This was, I believe, the only pair in the preserve.

Myiarchus crinitus. Crested Flycatcher. Summer resident. On several occasions, a bird was heard calling in the woods, where it may have nested.

Sayornis phoebe. Phoebe. Summer resident. A pair of Phoebes stayed near the Shack in 1924, and in 1925 a nest was built on the Shack.

Myiochanes virens. Wood Pewee. Summer resident. During 1924, a Pewee was heard calling in the woods of the Hook, where it probably nested.

Empidonax trailli alnorum. Alder Flycatcher. Summer resident. Several pairs nested in the grass bogs, and their nasal "rey-dwing" was heard until September.

Cyanocitta cristata cristata. Blue Jay. Summer resident and probable permanent resident. Jays were seen feeding their young in the alders on several occasions. This species was heard but twice during the winter.

Corvus brachyrhynchos brachyrhynachos. Crow. Probable permanent resident. Crows were observed feeding their young in the woods, and what I believed to be the nest of this species was found in a tree near the entrance to the preserve.

Sturnus vulgaris. Starling. Occasional visitant. A flock of these birds was seen in the preserve in the autumn of 1924. On several occasions one or two birds were observed in the preserve, where no doubt they came to feed.

Dolichonyx oryzivorus. Bobolink. Occasional visitant. Bobolinks were seen several times flying over the preserve. It is not improbable that they come to the bogs in the fall, before migrating.

Molothrus ater ater. Cowbird. Probable summer resident. A male was occasionally seen within the preserve, but I never observed a female there. However, a nest of a Maryland Yellowthroat (*Geothlypis trichas*) in Bog B contained, besides three eggs of the rightful owner, one egg of a Cowbird.

Agelaius phoeniceus phoeniceus. Red-winged Blackbird. Summer resident. Several pairs nested around Mud Pond.

Sturnella magna magna. Meadowlark. Occasional visitant. Several birds were seen flying over Grass Bog 2, where it is possible that they may come to feed.

Icterus galbula. Baltimore Oriole. Rare transient visitant. A single bird was heard singing in the woods during the spring migration. This species breeds commonly, however, in the surrounding territory.

Euphagus carolinus. Rusty Blackbird. Transient visitant. This species was seen only during the fall migration.

Quiscalus quiscula aeneus. Bronzed Grackle. Probable summer resident. One bird was observed flying to and from the Lonesome Pine, where it may have nested. This species was not uncommon during migration.

Astragalinus tristis tristis. Goldfinch. Probable summer resident. Several pairs were seen near Mud Pond during the nesting season, so it seems likely that this species breeds in the preserve.

Spinus pinus. Pine Siskin. Winter visitant. On February 28, 1925, a flock of seven birds was observed in the hemlocks west of Beaver Creek bridge.

Passerculus sandwichensis savanna. Savannah Sparrow. Summer resident. Several birds were heard and seen at Gyrinophilus Springs.

Zonotrichia albicollis. White-throated Sparrow. Transient visitant. These birds were not uncommon during both spring and fall migrations.

Spizella monticola monticola. Tree Sparrow. Winter visitant. This species appeared to be fairly common during April, but were only occasional from December to March.

Spizella pusilla pusilla. Field Sparrow. Probable summer resident. Several of these Sparrows were found, both on Observation Hill and at Gyrinophilus Springs, during the summer months.

Junco hyemalis hyemalis. Junco. Winter visitant and common transient. These birds seemed to prefer the heath bogs, as several of them were found there on every visit to the bogs during the winter and spring.

Melospiza melodia melodia. Song Sparrow. Summer resident. Song Sparrows were somewhat restricted to the bushy borders of both grass and heath bogs. No nests were found elsewhere.

Melospiza georgiana. Swamp Sparrow. Summer resident. This species was not uncommon in the grass bogs.

Passerella iliaca iliaca. Fox Sparrow. Transient visitant. Four birds were seen in the autumn of 1924.

Pipilo erythrophthalmus erythrophthalmus. Towhee. Transient visitant. A male was seen at the preserve during the spring migration of 1924.

Passerina cyanea. Indigo Bunting. Probable summer resident. Several birds were seen on Hemlock Ridge during the breeding season. The feathers of a male were found at the feeding log of the Sharp-shinned Hawk which nested in the preserve in 1924.

Piranga erythromelas. Scarlet Tanager. Summer resident. Professor Allen found a nest of this species in the preserve in 1915. I have seen the parents feeding young on the wing in the alders near the old cabin.

Petrochelidon lunifrons lunifrons. Cliff Swallow. Accidental visitant. Mr. W. J. Hamilton, Jr., saw one flying over Mud Pond on August 3, 1924.

Hirundo erythrogastra. Barn Swallow. Summer visitant. Barn Swallows came to Mud Pond nearly every evening from May until September for food and water.

Bombycilla cedrorum. Cedar Waxwing. Probable summer resident. Waxwings were seen on the preserve from May to September, but seemed especially abundant during June and July.

Vireosylva olivacea. Red-eyed Vireo. Summer resident. The Red-eyed Vireo was heard in full song from approximately May 15 to August 15, much later than any other bird excepting the Alder Flycatcher. Only one nest was found, which was in the alders bordering Mud Pond.

Mniotilta varia. Black and White Warbler. Probable summer resident. I am quite sure that this species nested in or near the hemlocks by Beaver Creek bridge, and probably elsewhere within the preserve.

Vermivora rubricapilla rubricapilla. Nashville Warbler. Summer resident. The only nest of this species found at McLean was in a clump of ferns in the

sphagnum, near Bog A. I am sure that at least two pair of these Warblers nested within the preserve in 1924.

Vermivora celata celata. Orange-crowned Warbler. Transient visitant. Professor and Mrs. Allen saw one of these Warblers at McLean during the spring migration.

Vermivora peregrina. Tennessee Warbler. Transient visitant. Two birds were seen near Bog B by Dr. Harper in the autumn of 1924.

Compsothlypis americana usneae. Northern Parula Warbler. Uncommon transient visitant and rare summer resident. Professor Allen found this species with young at McLean, and I have seen it several times in migration.

Dendroica tigrina. Cape May Warbler. Transient visitant. Dr. Harper found a flock of six in the shrubby borders of Bog B during the fall migration of 1924.

Dendroica caerulescens caerulescens. Black-throated Blue Warbler. Summer resident. Not uncommon as a breeder at McLean, and rather common as a transient.

Dendroica coronata. Myrtle Warbler. Transient visitant. Rather common in the spring migration.

Dendroica magnolia. Magnolia Warbler. Summer resident. Professor Allen has found the nest of this species at McLean, and I have seen adults feeding young on the wing.

Dendroica cerulea. Cerulean Warbler. Uncommon transient visitant. Two birds were seen at McLean in 1917 by J. Moesel, E. Smiley and Professor Allen.

Dendroica pensylvanica. Chestnut-sided Warbler. Summer resident. Rather common throughout the bushy portions of the preserve and along Beaver Creek.

Dendroica castanea. Bay-breasted Warbler. Transient visitant. One bird was seen in spring migration in 1924.

Dendroica striata. Black-poll Warbler. Transient visitant. Not uncommon in migration.

Dendroica fusca. Blackburnian Warbler. Rather common transient visitant and rare summer resident. Professor Allen has found this species breeding at McLean, but I have seen it only in migration.

Dendroica virens. Black-throated Green Warbler. Summer resident. At least three pairs of these Warblers nested on or near the preserve in 1924. On several occasions I saw a male feeding young on the wing.

Seiurus aurocapillus. Ovenbird. Summer resident. On June 24, 1924, I was fortunate enough to see an adult Ovenbird feeding several young on the wing. The immature birds were nearly full grown and but for their actions could hardly be told from the adult.

Oporornis agilis. Connecticut Warbler. Very rare spring transient. On June 4, 1924, a female was taken in a mouse-trap, set in the alders bordering Argus Brook, and is now No. 1898 in the Cornell University collection. This is

the first actual specimen taken, during spring migration, in the Cayuga Lake Basin, and is probably the first spring specimen ever collected in New York state.

Geothlypis trichas trichas. Maryland Yellowthroat. Summer resident. This species was found breeding both in the heath bogs and in the bushy portions of the preserve.

Icteria virens virens. Yellow-breasted Chat. Probable summer resident. One bird was seen several times in the bushy border of Bog A, and another was seen quite regularly at Gyrinophilus Springs.

Wilsonia canadensis. Canada Warbler. Summer resident. These Warblers were not uncommon in the bushy portion of the preserve. Several nests were found.

Setophaga ruticilla. Redstart. Transient visitant. I have no breeding records for this species.*

Anthus rubescens. Pipit. Transient visitant. One bird was seen flying over the preserve on November 2, 1924.

Dumetella carolinensis. Catbird. Probable summer resident. This species seemed to be restricted to the alder thickets and bushy portions of the preserve. The birds were heard singing through the breeding season, but no nests were found.

Toxostoma rufum. Brown Thrasher. Probable rare summer resident. This species was observed near Gyrinophilus Springs during June and July.

Nannus hiemalis hiemalis. Winter Wren. Uncommon transient visitant and rare summer resident. I saw but one bird, undoubtedly a migrant, but Professor Allen has found this species nesting near Beaver Creek.

Cistothorus stellaris. Short-billed Marsh Wren. Rare summer resident. Professor Wright has found this species at McLean in the grass bogs near the pond.

Sitta carolinensis carolinensis. White-breasted Nuthatch. Probable permanent resident. This species was quite uncommon at all seasons.

Sitta canadensis. Red-breasted Nuthatch. Transient visitant. One bird was seen in the spring of 1924.

Penthestes atricapillus atricapillus. Chickadee. Probable permanent resident. Several pairs were seen throughout the year. One pair nested by the Shack in 1924.

Regulus satrapa satrapa. Golden-crowned Kinglet. Winter resident. During the colder months the Kinglets were fairly common throughout the preserve.

Regulus calendula calendula. Ruby-crowned Kinglet. Transient visitant. This species was quite common in spring.

Hylocichla mustelina. Wood Thrush. Transient visitant. One bird was heard singing on May 31, 1924.

* Although it breeds commonly in the surrounding country, I have only seen it, however, during migration.

Hylocichla fuscescens fuscescens. Veery. Summer resident. Veeries seemed to be quite abundant at McLean. Several nests were found in the woods.

Hylocichla ustulata swainsoni. Olive-backed Thrush. Transient visitant. Dr. Harper saw two birds along Sphaerium Stream in the autumn of 1924.

Hylochichla guttata pallasi. Hermit Thrush. Transient visitant. This species was not uncommon during migration.

Planesticus migratorius migratorius. Robin. Summer resident. Robins breed in small numbers at McLean, usually nesting in the more open woods or in the scattered trees in the bogs.

Sialia sialis sialis. Bluebird. Summer resident. This species was found nesting both in Bog B, and by the Gyrinophilus Springs.

## Mammals

Parascalops breweri. Hairy-tailed Mole. Not uncommon in the moist woodland and occasional in the alders. This species was previously known from the Cayuga Basin by one specimen, taken at North Spencer, New York, by Messrs. Reed and Hankinson in 1902.

Condylura cristata. Star-nosed Mole. Fairly common in the alder thickets.

Sorex personatus personatus. Masked Shrew. Two specimens were taken at McLean, one in Round Bog A, and the other in the wet alders bordering Mud Pond.

Sorex fumeus fumeus. Smoky Shrew. Rather uncommon in the beech-maple woods, and rare in the alders.

Blarina brevicauda talpoides. Short-tailed Shrew. This species was probably the most widely distributed of any mammal in the preserve, and was common everywhere.

Myotis lucifugus lucifugus. Little Brown Bat. Four specimens were taken over Mud Pond.

Lasionycteris noctivagans. Silvery Bat. Twelve specimens were shot over the pond.

Eptesicus fuscus fuscus. Big Brown Bat. One specimen was collected at the pond by Dr. Harper.

Nycteris borealis borealis. Red Bat. A single specimen was taken at Mud Pond.

Procyon lotor lotor. Raccoon. This species was observed in the beech-maple woods. Coon tracks were often seen along the waterways, especially Beaver Creek.

Mustela noveboracensis noveboracensis. New York Weasel. A single animal was seen by the old cabin, carrying a young Rabbit.

Mustela vison mink. Mink. Local trappers reported that several of these furbearers were taken during 1923 and 1924. To me, Beaver Creek seemed to be an ideal habitat for this species.

Mephitis nigra. Skunk. Not common at McLean. One specimen was taken from a woodchuck burrow on Hemlock Ridge.

Vulpes fulva. Red Fox. Foxes were not uncommon at McLean, and at least two used dens were found near the preserve. Tracks of these animals were seen quite often along Sphaerium Stream.

Marmota monax rufescens. Woodchuck. This species seemed to be quite common within the preserve.

Tamias striatus lysteri. Chipmunk. Quite common on the more open slopes of Hemlock Ridge, and occasional throughout the wooded portions of the preserve.

Sciurus hudsonicus loquax. Red Squirrel. Not uncommon in the beech-maple woods and in the scattering stands of hemlock.

Sciurus carolinensis leucotis. Gray Squirrel. In 1913, Mr. J. T. Needham saw a Gray Squirrel in the preserve. As far as known, no others have been seen there.

Peromyscus leucopus noveboracensis. Deer Mouse. This mouse was probably the most abundant mammal of the preserve. It was found in the woods, the alders, and even the small "islands" in Bog B.

Microtus pennsylvanicus pennsylvanicus. Meadow Mouse. This species was quite common both in the grass bogs and in the heath bogs. It ranked about second in abundance of the mammals at McLean.

Ondatra zibethica zibethica. Muskrat. Muskrats were common both in Mud Pond and along Beaver Creek. Several houses were built around Mud Pond in 1924.

Rattus norvegicus. House Rat. One individual was seen near the pond in August, 1924, and was probably the one which was taken later near the Shack.

Mus musculus musculus. House Mouse. A single specimen was taken in the middle of Bog A, in 1923.

Zapus hudsonius hudsonius. Meadow Jumping Mouse. A female of this species was captured in Grass Bog 1 in 1923, and subsequent trapping failed to reveal any others.

Napaeozapus insignis insignis. Woodland Jumping Mouse. These Mice were not uncommon in the alders bordering Argus Brook, where five specimens were collected.

Lepus americanus virginianus. Varying Hare. According to hunters, this species was formerly quite common along Beaver Creek, but now apparently is exterminated there.

Sylvilagus floridanus mearnsii. Cottontail. Common at McLean. Apparently the only checks to its increase were Horned Owls and Foxes.

# COLLECTING METHODS FOR INVERTEBRATES

By P. W. Claassen and C. K. Sibley

*Methods of collecting.* Hand picking, nets, tent traps, bottle traps, and light traps were the methods used to collect specimens of the invertebrates. Since most attention was given to the insects, the methods discussed, unless otherwise specified, apply to them.

The nets used were the ordinary air and water nets—dip nets, plancton nets and sieve nets. The last named was most useful for collecting aquatic burrowers.

Two sorts of little known traps proved so very useful for bog collecting that a few words should be said concerning them. They yielded much material that was not obtained by any other means.

*Bottle traps.* Many aquatic insects dwell in the bogs, hidden among the sphagnum and other vegetation. If a hole is made in a bog cover it soon fills up with water. In the water one sees many insects, chiefly beetles. If one tries to catch them they quickly retreat to the edge of the pool and disappear among the vegetation.

It was for this reason that bottle traps were employed. Wide mouth bottles eight ounce size were used. A hole was cut through the cork large enough to admit placing a cone of celluloid inside with a small opening projecting within as shown in figure 11. This bottle trap was then inserted horizontally into the vegetation as shown in figure 12. A small piece of meat or bait of some sort was sometimes placed in the bottle to attract the scavengers and carnivores.

These bottle traps captured many beetles that otherwise might have escaped notice.

FIG. 11. A BOTTLE TRAP

FIG. 12. DIAGRAM SHOWING HOW THE BOTTLE TRAP WAS SET

*Tent traps.* Two sorts of tent traps were used by us; both adapted from the original used by Professor Needham (see Bull. 124, New York State Museum,

1907, pages 167-172, plate 8). One of us (Claassen) during the summer of 1916 used a small tent trap of the form shown in figure 13. The tents were made of cheese cloth about three feet in diameter at the base, gradually tapering to a point at the tip, and a heavy wire rim was run through a hem around the bottom

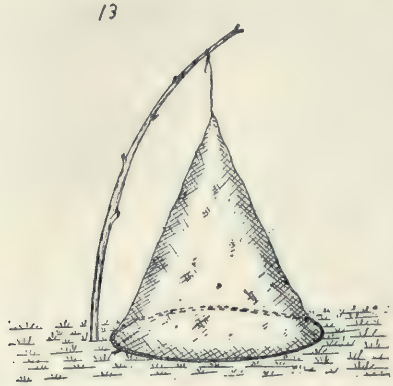


FIG. 13. A SMALL CHEESE-CLOTH TENT TRAP, THAT IS MANIPULATED LIKE AN INSECT NET FOR THE REMOVAL OF THE CATCH

of the net to keep the base extended. The projecting ends of the wire were bent parallel and served for a handle. At the tip of the cone a heavy string was attached and by means of the string the tent was tied to a branch of a tree or to a stick stuck in the ground, and thus held in place. The wire at the base was placed closely to the ground and held in place by the weight of a few handfuls of


FIG. 14. MAP SHOWING THE LOCATION OF TENT TRAPS (NUMBERED CIRCLES), AND BOTTLE TRAPS (SQUARES).

sphagnum or mud. As the adult insects emerge they crawl up the side of the cone-shaped net and thus are easily swept into the tip of the tent when swung as a net, and transferred to cyanide bottles.

Tents of this form were placed about the bogs as indicated in figure 14. They yielded mainly minute Diptera. In the following lists the species collected by this method are marked with a number preceded by a capital letter T. Then T8 after the name of a midge indicates that it was taken in a tent trap at station 8 on this map.

One of us (Sibley), during the summer of 1924, used the mosquito bar tent that is sold by the army supply houses. This is the size and shape of an army shelter tent. This was set up over a portion of the stream bed, or over the shallows in the pond with the edges fastened down so that nothing within the area covered by the tent could get outside, and also, so that nothing outside the tent could get in. The trap was used with great success on Mud Pond and on Sphaerium and Inlet Brooks.

Tent traps definitely determine what is the habitat of the immature stages of the insects caught in them. They also yield quantitative as well as qualitative results.

Certain of the insects were obtained by rearing them from their immature stages. For this we used rearing cages, which were cylinders of galvanized wire screening, fourteen meshes to the inch, folded at the ends. This mesh was too coarse for the micros., so, for them we used cages made of copper cloth, fifty meshes to the inch. Substantial additions to our knowledge of the caddis fly fauna were made in this way.

*Animal habitats.* The following conspectus of the principal animal habitats of the reservation was prepared by J. G. Needham preparatory to the intensive collecting of insects and other invertebrates during the summer of 1924.

## Animal Habitats

### I. *Mud Pond*

| | | |
|---|---|---|
| Surface | Potamogeton beds | Decodon clumps |
| Bottom | Chara beds | Inlet mud-fans |
| Open water | Banks | Outlet sedge tussocks |

### II. *Streams*

| | *Bottom* | *Obstructions* | *Banks* |
|---|---|---|---|
| Inlet Brook | | | |
| Sphaerium Brook | muck | leaf drifts | eroding |
| Argus Brook | gravel | logs | aggrading |
| Beaver Creek | mud | stones | root-fringed |

III. *Grass Bogs*

| Holding units | Shrub clumps<br>Grass and sedge tussocks | Intervales | In green stuff<br>In dead stuff |
|---|---|---|---|

IV. *Round Bogs*

Open pools—cover: By zones; By depth

V. *Ridges*

Vegetation—leaf mold—soil

VI. *Miscellaneous*

Every kind of plant and every plant product, a separate habitat.
Every chemical and physical influence, a factor affecting distribution.

# INSECTS AND SOME OTHER INVERTEBRATES

BY C. K. SIBLEY AND OTHERS

This is a preliminary listing of the insects of the Lloyd-Cornell Reservation. It also includes any invertebrate groups, other than insects, on which I have some ecological data. It is mainly based on the results of the extensive collecting of the summer of 1924, during which I lived on the reservation and for part of the time and had the help of Mr. D. J. Leffingwell and Mr. Myron Gordon. In the study of the Trichoptera, which have had my first interest, I have had the advice and help of Dr. C. Betten. In other orders I have submitted specimens to specialists for determination and they have made up the lists. More specific acknowledgment will be found in connection with the several lists, on subsequent pages, as follows:



In all the orders of insects the entomological collections of Cornell University have been drawn upon for records. Collections made by Dr. P. W. Claassen in 1916, and by Mr. Sidney Robinson in 1925, also have added considerably to the lists.

## INVERTEBRATES OTHER THAN INSECTS

### *Porifera*

*Spongilla lacustris.* Rather common on stones in the gravelly part of Sphaerium Brook during August and September.

While the sponge was unbranched, the spicules agreed very closely with the figures for this species.

### *Coelenterata*

*Hydra viridissima.* In weedy shallows of Mud Pond, August.

### *Annelida*

*Placobdella parasitica.* This large leech was rather common in Mud Pond, preferring the shallows.

*Stylaria lacustris.* Rather common in the pond during August and September, found on the bottom.

Several other annelids were present and some were collected but have not been identified.

*Chilognatha*

These were determined by J. W. Bailey.

*Spirobolus marginatus.* B. Cr., September 14.

*Polydesmus serratus.* Shack; SE. Sl., August, September.

*Parajulus immaculatus.* Shack, August.

*Mollusca*

These aquatic Mollusca were determined by Dr. F. C. Baker.

*Succinea ovalis.* SE. Sl.; B. Cr., September.

*S. retusa.* S. Br., June; A. Br., September.

*Pyramidula alternata.* SE. Sl., September.

*Polygyra tridentata.* SE. Sl., September.

*P. thyroides.* A. Br., September.

*Planorbis trivolous.* S. Br., June.

*Physa gyrina* (?). S. Br., June.

*P. sp.* S. Br., July, found on gravelly bottom.

*Ancylus rivularis.* S. Br., September, found on stones in gentle current.

*Lasmigona compressa.* This species and the following one occur in Sphaerium Brook in large numbers.

Lasmigona is common in the gravelly portion of the stream where the current is stronger. It was formerly thought that the species was restricted to this habitat. However, during the past summer Leffingwell and myself found several specimens in the upper portion of Sphaerium Brook where the current is slight and the bottom is composed mainly of soft mud.

*Sphaerium sulcatum.* Found in Sphaerium Brook. This species lives only in soft mud where there is but little current. Hence, in Sphaerium Brook it is restricted to the extreme upper and lower portions of the stream where favorable conditions obtain. In these situations it is extraordinarily abundant.

*Pisidium sp.* Found in Mud Pond near outlet. Apparently not common.

*Anodonta footiana.* Found in mud of upper Sphaerium Brook in small numbers.

The following shells were collected by sifting sphagnum from the borders of Mud Pond; collectors M. D. Leonard and F. C. Fletcher; determined by H. A. Pilsbry.

*Cochlicopa lubrica morseana.* This form is new to the state, its range being mainly in the Alleghenies and southwestward.

*Gonyodiscus cronkhitei catskillensis.*

*Punctum pygmaeum.*

*Euconulus chersinus.*

*Striatura ferrea.*

*Polita hammonis.*

Several very young specimens of *Polygyra sp.* undet.

# CRUSTACEANS

Unless otherwise indicated, all crustacea were taken in Mud Pond.

### *Cladocera*

*Daphnia longispina.* In all parts of pond through summer; rare during late July and early August.

*Simocephalus vetulus.* In all parts of pond during August and September.

*S. serrulatus.* In all parts of pond during August and September.

*Scapholeberis mucronata.* Restricted to open water very near shore. July 4 to August 9, very common. August 17, few.

*Ceriodaphnia quadrangula.* All parts of pond; common throughout season; very common during July.

*Bosmina longirostris.* Open water throughout season; most common near surface; very common during July.

*Camptocercus rectirostris.* Very common in Ceratophyllum bed during September; few in weedy shallows; none in open water.

*Pleuroxus denticulatus.* In all parts of pond from August 17 to September 21.

*P. hamulatus.* Shallows near small inlet. September 13, few.

*Chydorus sphaericus.* In all parts of pond, July 4 to September 22, very common among vegetation.

*Alona guttata.* Weedy shallows, September 6; Ceratophyllum, September 10, few.

### *Copepoda*

*Cyclops viridis.* Common throughout season everywhere in pond; nauplii, August 26.

*Cyclops sp.* (probably *C. ater*). Weedy shallows, August 22.

*Canthocamptus minutus.* Found in pond during the spring; August, September, common.

### *Ostracoda*

*Cypridopsis vidua.* Weedy shallows, August, September, common.

*Cypris sp.* Open water, July, August, September, few.

*Cypris sp.* On Ceratophyllum, September, common.

### *Amphipoda*

*Hyalella knickerbockeri.* Very common among vegetation throughout the year.

### *Decapoda*

*Cambarus bartoni.* Gravelly portion of Sphaerium Brook; not common.

# INSECTS

## PLECOPTERA, Stoneflies

The Plecoptera were determined by Dr. J. G. Needham.

*Pteronarcys biloba.* Nymphs were taken in the Mill Pond brook, McLean. Not found within the preserve.

*Acroneuria lycorias.* Shack, June 23. Nymphs: I. Br., September.

*Perla capitata.* Adults: S. Br.; Mud P., June, July. Nymphs: S. Br., August.

*Peltoperla arcuata.* Gyrinophilus Springs, August.

*Isoperla bilineata.* Adults: I. Br.; S. Br.; Mud P.; Gyrinophilus, June to August. Nymphs: I. Br.; Gyrinophilus Springs, July, August.

*Leuctra decepta.* Adults: A. Br.; I. Br.; Gyrinophilus, August, September.

*L. truncata.* Adults: Shack; I. Br.; S. Br., July to September. Reared in large numbers from Inlet Brook in September. Nymphs: I. Br., May to September.

*Nemoura sp.* Adults: A. Br.; I. Br., June, September. Nymphs: I. Br., May, June.

## EPHEMERIDA

Determinations by J. G. Needham

*Hexagenia recurvata.* Not common, S. Br., June 2.

*Leptophlebia mollis.* A. Br., September 3.

*Leptophlebia betteni.* S. Br., common in the gravelly portion, June 5 to 30.

*Leptophlebia sp?.* June 13.

*Blasturus cupidus.* S. Br., May 7 to June 10. Our earliest species.

*Ephemerella femenina.* S. Br. and I. Br., June 2 to 23 abundant; females only.

*Ephemerella sp?.* June 17.

*Tricorythus allectus.* August 26.

*Caenis diminuta.* Mud P., June 22.

*Caenis hilaris.* Mud P., June 19 to August 26, large swarms June 24. Our smallest species.

*Chirotenetes albomanicatus.* Few seen, July 13 and August 26.

*Ameletus ludens.* Nymphs only, I. Br., May 22.

*Callibaetis fluctuans.* A few frequently taken, June 28 to September 12.

*Baetis species?.* Nymphs seen in brook bed, S. Br.

*Ecdyurus maculipennis.* June 29.

*Heptagenia interpunctata.* I. Br., June.

*Heptagenia, 2 sp?* undetermined. Nymphs seen in all brook beds, sparingly; adults taken June 2, 29, August 25, September 20.

## ODONATA

This list includes thirty species of Anisoptera and sixteen of Zygoptera. The most noteworthy record for this group is that of *Gomphus cornutus.* One male was taken, it being the first known occurrence of this species in the eastern states.

Acknowledgments are due Dr. J. G. Needham who made all determinations.

## ANISOPTERA

*Gomphus villosipes.* A cast nymphal skin and large and small nymphs were found in upper Sphaerium Brook at the Mud Pond outlet. Two adult males were taken around Mud Pond, June 28 and July 7.

*Gomphus lividus.* This was the commonest of the Gomphinae. Nymphs were most abundant in Sphaerium Brook near the upper bridge. A few occurred in mud bars near the lower bridge. When slack water and soft bottom again appeared in the lower part of the stream the nymphs once more became numerous.

The first adult was taken on June 12th. On this date large numbers emerged as was shown by the cast skins along the banks of Sphaerium Brook. Nymphs in the rearing cages emerged on June 13th and 17th. One male was caught at Mud Pond on June 21st.

*Gomphus spicatus.* Only nymphal skins of this species were found. Two were picked up along Sphaerium Brook on June 12 and 16.

*Gomphus cornutus.* One male caught around Mud Pond on July 5.

*Gomphus scudderi.* Several specimens taken while they were hawking beside Sphaerium Brook, September 2, 1925 (J. D. Hood).

*Gomphus descriptus.* Sphaerium Brook, May 19th.

*Boyeria vinosa.* Nymphs were common on submerged sticks and stones in Sphaerium Brook and less numerous in Argus and Inlet Brooks. A male imago emerged on July 11 and another on July 22. Female imagoes emerged on July 22 and 26. A female was caught on the southeast slope on July 18 and another along Sphaerium Brook on August 15.

*Aeschna constricta.* Nymphs were present on sticks in Sphaerium Brook in small numbers and also in the Chara bed on the south side of Mud Pond. A male and a female emerged from the pond on July 26. A female emerged from the brook on August 14. Female—Bog A, August 26. Male—The Shack, September 16.

*Aeschna umbrosa.* Very common in August.

*Aeschna canadensis.* Common in August.

*Anax junius.* Nymphs occurred in the weed beds on the south side of the pond. Adults were over the pond from the 20th of June until September. They

were most numerous during late July. Oviposition took place in the pond during late July and early August, beginning July 15.

*Cordulegaster diastatops.* This was probably the commonest dragonfly in the streams. Nymphs were present in the mud bars in all three streams. Adults during the last part of May.

*Tetragoneuria cynosura.* One male was taken around Mud Pond July 1.

*Tetragoneuria spinosa.* Nymphs were found in the shallows in the pond, fully grown, on May 27. Two males were caught on the pond on June 19 and 26.

*Somatochlora walshii.* One male taken beside Beaver Brook September 2, 1925 (J. D. Hood).

*Somatochlora williamsoni.* One specimen taken in transformation at the edge of Mud Pond by J. G. Needham in 1916.

*Somatochlora elongata.* One female was taken on Bog A July 18.

*Dorocordulia libera.* One male, Mud Pond, June 26.

*Leucorhinia intacta.* Nymphs were found in the weedy shallows in the pond. Adults were common over the pond from July 5 until the middle of August.

*Sympetrum semicinctum.* This was a common species over Bog A from August 10 on. In addition a male was caught over Grass Bog 3 on August 22 and a female along Beaver Brook on September 20.

*Sympetrum albifrons.* Females were taken over Bog A on the 12th and 23rd of August and over Bog B on August 28. Two pairs were taken in copulo on Mud Pond on September 16.

*S. rubicundulum.* This species was on the wing from July 11 throughout the season. Two pairs were taken in copulo at the pond on October 5. Adults were taken around Argus Brook, Mud Pond, Bogs A and C, and Grass Bog 3.

*Sympetrum obtrusum.* This species was caught from July 11 until the last of August. There are records from Bogs A and B, and Grass Bogs 1 and 3.

*Sympetrum costiferum.* One male, August 30, Mud Pond (J. W. Hood).

*Sympetrum vicinum.* Common in August and September.

*Pachydiplax longipennis.* Three male imagoes were taken over Mud Pond on June 18, 22 and 27. One female on June 28.

*Ladona julia.* Male imago, Mud Pond, June 20; male imago, Mud Pond, June 28.

*Libellula quadrimaculata.* This was only found at the pond. Males were taken from June 19 to July 9.

*Libellula pulchella.* Nymphs were found on the shallows and particularly in the Chara bed at outlet of the pond. Imagoes were observed over the pond about the 15th of June. However, they emerged over a long period for one was reared on July 28. This was a common species around the pond in August.

*Plathemis lydia.* A male was taken on Grass Bog 2 on June 16, and a female and two males over Mud Pond on June 26.

### Zygoptera

*Agrion maculatum.* The nymphs of this species were very common in Sphaerium Brook between the two bridges. They occurred in the other streams in lesser numbers. The imagoes appeared on June 16. They continued to emerge until the last of June. The imagoes were very common along Sphaerium and Argus Brooks throughout the remainder of the season.

*Lestes congener.* One male, September 1 (J. D. Hood).

*Lestes rectangularis.* Nymphs were quite common in the pond on the Potamogetons. Adults emerged about August 10. Imagoes were taken on West Ridge, Grass Bog 1 and Bog A.

*Lestes disjuncta.* One female, the Hook, August 24; three males, one female, August 30 (J. D. Hood).

*Lestes forcipata.* One male, September 1.

*Argia violacea.* One male, Mud Pond, August 4.

*Chromagrion conditum.* Two females of this fine species were caught on Sphaerium Brook on June 16, and two males on Hemlock Ridge on June 23.

*Amphiagrion saucium.* This species was fairly common around Mud Pond early in July. Pair in copulo. Beaver Brook, July 16.

*Nehallenia irene.* This species was found around the pond early in June, although never common.

*Enallagma exsulans.* One male, Mud Pond, June 10.

*Enallagma ebrium.* Bog A, not common; four males, July 22.

*Ischnura verticalis.* Sphaerium Brook, common.

*Ischnura posita.* Sphaerium Brook, less common.

## ORTHOPTERA

The bogs furnished poor collecting for Orthoptera since only sixteen species were collected and none of these was abundant within the preserve.

All were identified by Mr. Wm. T. Davis.

### Locustidae

*Acridium granulatum.* Mud P., June.

*Tettigidea lateralis.* Mud P.; B. Cr., May to September.

*Chorthippus curtipennis.* Bog B; Bog 3, August, September.

*Camnula pellucida.* B. Cr., August.

*Chortophaga viridifasciata.* Bog A, May, July.

*Podisma glacialis variegata.* A. Br.; H. R., August, September. "A species of high altitudes and latitudes."

*Spharagemon bolli.* B. Cr., August, September.

*Dissosteira carolina.* B. Cr., August, September.

*Melanoplus bivittatus.* Bog 3; Shack; B. Cr., August, September.

*M. femur-rubrum.* B. Cr., August, September. Not taken within the preserve.

#### Tettigoniidae

*Scudderia furcata.* Bog 3; Shack, August, September.

*Conocephalus brevipennis.* Bog A; Bog 1; Bog 3; A. Br., August, September.

*Ceuthophilus terrestris?* Mud P., June.

#### Gryllidae

*Oecanthus nigricornis.* Bog B; Bog 3; S. Br., September.

*Gryllus assimilis* form *neglectus.* B. Cr., August, September.

*Nemobius fasciatus.* Shack, August.

### THYSANOPTERA

With the exception of a single species taken in September, the material of this order was all collected May 19, 1925, by M. D. Leonard and J. D. Hood. The list could be greatly extended by a little summer collecting. Determinations by J. Douglas Hood.

*Heterothrips arisæmæ* Hood. Both sexes abundant in the flowers of Jack-in-the-Pulpit (*Arisæma triphyllum*).

*Chirothrips manicatus* (Haliday). One female taken by sweeping grass.

*Aptinothrips rufus* var. *stylifer* Trybom. Common on grass. It is interesting to note the complete absence of the form with six-segmented antennæ, at least at this time of year. Females only.

*Frankliniella tritici* (Fitch). One female in catkin of willow.

*Ctenothrips bridwelli* Franklin. Not rare on the lower surface of leaves of May Apple and Skunk Cabbage. Females only.

*Thrips impar* Hood. Abundant in flowers of *Impatiens,* September 2, both sexes.

*Haplothrips verbasci* (Osborn). Common on Mullein, both sexes.

*Rhynchothrips pruni* Hood. Two females, under bark of *Prunus* sp.

*Hoplothrips karnyi major* Hood. Several specimens of both sexes and numerous nymphs, under bark on fungus-covered stump.

### HEMIPTERA

Acknowledgements are due Dr. H. H. Knight for assistance with the Miridae and to Mr. H. G. Barber for identification of the Lygaeidae.

There are undoubtedly many gaps in this list.

#### Corixidae

*Arctocorixa alternata.* Mud P., July.

### Notonectidae

*Notonecta undulata.* Mud P., June, July.
*N. insulata.* Mud P., July, September.
*N. irrorata.* Mud P., July.
*N. variabilis.* Mud P., July.

### Nepidae

*Ranatra americana.* July.

### Belostomidae

*Belostoma flumineum.* Mud P., July, August.

### Gerridae

*Gerris canaliculatus.* Mud P., October. This is a southern form and rather rare in this region.
*G. marginatus.* Mud P., July, October.
*G. remigis.* A. Br.; S. Br., September.

### Miridae

*Chlamydatus pulicarius.* Bog A, July, August.
*Plagiognathus politus.* Shack, July.
*P. albonotatus.* July (Knight).
*P. obscurus.* July.
*P. annulatus* var. *cuneatus.* Bog 3, August.
*P. chrysanthemi.* July.
*P. fulvidus.* A. Br., July.
*Microphylellus tsugae.* July (Knight).
*Psallus alnicenatus.* July (Knight).
*Dicyphus famelicus.* H. R., September.
*Hyaliodes vitripennis.* A. Br., August.
*Deraeocoris nubilus.* SE. Sl., August.
*D. poecilus.* Bog 1, September.
*Halticus apterus.* July.
*Strongylocoris stygica.* S. Br.; Bog B; W. R., July to August.
*Ilnacora malina.* July.
*Lopidea media.* Bog B; Bog C, August, September.
*Orthotylus neglectus.* July (Knight).
*O. dorsalis.* July.
*O. alni.* July (Knight).
*Diaphnidia pellucida.* Bog 1, August.

*Ceratocapsus pumilus.* Mud P., September; I. Br., September.
*Collaria meilleurii.* Bog 1; Bog 2, July to September.
*Miris dolabratus.* Bog 1; Bog 2; B. Cr., July.
*Trigonotylus ruficornis.* Shack, August.
*Stenodema trispinosum.* I. Br., July.
*S. vicinum.* Bog 3, May to September.
*Platytylellus borealis.* July.
*P. insignis.* July.
*Capsus ater.* July.
*Lygus pratensis* var. *oblineatus.* July to September, generally common.
*L. pratensis* var. *strigulatus.* August.
*L. vanduzeei.* S. Br.; A. Br., July.
*L. pabulinus.* SE. Sl.; B. Cr., July to October.
*L. ostryae.* SE. Sl., September.
*L. alni.* July (Knight), a northern species.
*L. communis.* July (Knight).
*L. johnsoni.* July (Knight), a northern species.
*L. belfragii.* July (Knight).
*Polymerus opacus.* Bog 2, July.
*P. basalis.* Shack, July.
*Poecilocapsus lineatus.* Bog 2; B. Cr.; S. Br., July.
*Horcias dislocatus,* typical. S. Br., July.
*H. dislocatus* var. *limbatellus.* S. Br., July.
*H. dislocatus* var. *affinis.* S. Br., July.
*H. dislocatus* var. *nigritus.* S. Br., July.
*Adelphocoris rapidus.* Bog 1; Bog 2, July to August.
*Stenotus binotatus.* Shack, July.
*Phytocoris tibialis.* A. Br., August.
*P. angustatus.* Bog B, September.
*P. erectus.* Bog B, August.

### Anthocoridae

*Anthocoris borealis.* Bog 2, August.

### Nabidae

*Nabis subcoleoptratus.* July.
*N. ferus.* August to September, common.

### Reduviidae

*Reduvius personatus.* Shack; Mud P., July to August.
*Zelus exsanguis.* Shack, June.
*Sinea diadema.* Bog A; Bog 3, September.

### Cimicidae

*Cimex pilosellus.* From immature male, *Lasionycteris noctivagans* shot over Mud P. by D. J. Leffingwell, August 12, 1924.

### Tingidae

*Corythucha marmorata.* July.
*C. pergandei.* Bog 2; Mud P.; Shack, June to August.

### Lygaeidae

*Nysius californicus.* Bog A, August.
*Ischnorhynchus geminatus.* May, July, August.
*Cymus discors.* I. Br., July.
*C. angustatus.* S. Br., July; Bog B, September.
*Ligyrocoris sylvestris.* Bog 2, August.
*Zeridoneus costalis.* B. Cr., August.
*Ortholomus scolopax.* Bog A, August.
*Perigenes constrictus.* Shack, July.

### Neididae

*Neides muticus.* SE. Sl., September.

### Aradidae

*Neuroctenus simplex.* H. R., September.

### Alydidae

*Protenor belfragei.* Bog 2; Bog 3; Mud P., August to September.

### Corizidae

*Corizus bohemanni.* B. Cr., September.
*C. crassicornis.* July to August.

### Pentatomidae

*Brochymena quadripustulata.* Bog 1; Bog 2, June to September.
*Mormidea lugens.* Bog 1; Bog 2; W. R., June to September.
*Euschistus euschistoides.* Shack; B. Cr., September.
*E. tristigmus.* June, July, September, generally distributed.
*E. variolarius.* Bog 3; B. Cr., September.
*Coenus delius.* B. Cr., September. Common on mullein.
*Cosmopepla bimaculata.* July.

*Banasa calva.* Bog 1; Bog B; A. Br., June to September.
*Perillus exaptus.* Shack, August.
*Podisus maculiventris.* Bog 1; Bog B, August, September.
*P. modestus.* June to September, generally distributed.
*P. placidus.* S. Br., September.

### Cydnidae

*Corimelaena pulicularia.* August.

## HOMOPTERA

Acknowledgements are due Dr. J. L. Buys for determining the Cicadellidae and for furnishing additional records from his own collection.

### Cicadidae

*Tibicen canicularis.* B. Cr., August, common on Rhus typhina.

### Cercopidae

*Aphrophora quadrinotata.* August to September, generally distributed.
*A. sigsoretti.* Bog 3, August, September.
*Lepyronia quadrangularis.* Bog 1; Mud P., August to September.
*Philaenus lineatus.* Bogs 1, 2, 3, August.
*Clastoptera proteus* var. *saint-cyri.* July to August, generally distributed.
*C. proteus* var. *pini.* July to September, generally distributed.
*C. obtusa.* Shack; Bog 3, September.

### Cicadellidae

*Agalliopsis novelli.* July, 1904.
*Agallia 4-punctata.* May, 1921.
*Idiocerus suturalis.* Bog 2, July.
*I. suturalis* var. *lunaris.* July, 1919.
*I. flavidorsum.* Bog A, July; Bog B, September.
*I. lachrymalis.* Bog A; Shack; S. Br., July, August.
*I. pallidus.* A. Br.; Bog 3, August to September.
*Macropsis trimaculata.* July, 1920.
*Oncopsis variabilis.* Bog 1, August.
*Graphocephala coccinea.* Common, generally distributed, August to September.
*Draeculacephala mollipes.* May, July.
*D. noveboracensis.* July.
*D. angulifera.* May, July, August.
*D. minor.* July.

*Oncometopia lateralis.* August, 1900.
*Helochara communis.* July, 1919.
*Gypona octolineata* var. *striata.* Shack; Hook; Bog 1, August, September.
*Acucephalus nervosus.* Mud P.; Bog 2, August.
*A. albifrons.* Bog B; Shack, August.
*Parabolocratus viridis.* Bog 1, July.
*Scaphoideus immistus.* Common, generally distributed, August, September.
*Platymetopius acutus.* Bog B; Bog 1; B. Cr., August, September.
*P. cuprescens.* July, 1919.
*Deltocephalus configuratus.* May, 1921.
*D. sayi.* July.
*D. misellus* (?). July.
*D. inimicus.* Shack; B. Cr., July, August.
*Euscelis parallelus.* July, 1919.
*E. instabilis.* Bog A, July, August.
*E. curtisii.* July.
*Phlepsius incisus.* August.
*Thamnotettix nigrifrons.* August.
*T. inornatus.* Bog 1; Bog 2, August.
*T. morsei.* Bog B, September.
*T. clitellarius.* July.
*T. melanogaster.* July.
*T. decipiens.* Bog B, September.
*Chlorotettix unicolor.* Bog 3, September.
*C. tergatus.* A. Br.; Shack, July, August.
*Jassus olitorius.* Hook; A. Br., September.
*Cicadula sexnotata.* August.
*Balclutha impicta.* August.
*Balclutha punctata.* Common, generally distributed, May to September.
*Eugnathodus abdominalis.* Bog A, July.
*Dikraneura mali.* Bog 1; H. R., August, September.
*D. fieberi.* Bog 2, July.
*Typhlocyba querci* var. *gillettei.* July, 1919.
*Eupteryx flavoscuta.* July, 1919.
*E. flavescens.* July, 1919.
*Empoasca smaragdula.* July, 1919.

### Fulgoridae

*Cixius basalis.* H. R., September.
*C. coloepium.* Shack, June, August.
*C. pini.* A. Br., August.
*Bruchomorpha oculata.* Bog B, September.

*Aphelonema histrionica.* August.
*Lamenia obscura.* Bog 2, September.
*Otiocerus coquebertii.* Shack, August.
*Phyllodinus nervatus.* S. Br., June.
*Stobaera pallida.* August.
*Liburnia puella.* August.

### Psyllidae (Chermidae)

*Livia vernalis.* Bog A, August. On Pinus strobus at margin of bog.
*Aphalara veaziei.* July.
*Psylla striata.* June, July.

### Membracidae

*Campylenchia latipes.* July.
*Ceresa diceros.* Mud P.; Bog 1; Bog B, August to September.
*C. basalis.* August to September, generally distributed.
*C. taurina.* Bog 3, August.
*Stictocephala inermis.* August.
*Thelia bimaculata.* July.
*Telamona decorata.* Bog 3, September.
*Entylia bactriana.* B. Cr.; Bog B, September.
*Publilia concava.* B. Cr., September.

# NEUROPTERA

The Chrysopidae and Hemerobiidae were identified by Dr. R. C. Smith.

## Sialididae

*Sialis infumata.* Adults: I. Br., June. Larvae were found also in the other streams in the the preserve.

*Chauliodes* sp. One wing, probably of C. pectinicornis, was found on the shore of Mud Pond.

*Nigronia serricornis.* Adults: S. Br., June, very common. Larvae very common.

## Hemerobiidae

*Hemerobius humuli.* Mud P.; S. Br.; Shack, June. Often seen.

*H. stigmaterus.* Bog 1; S. Br., September.

## Chrysopidae

*Chrysopa chi.* June (R. C. Smith).

*C. nigricornis.* Shack, June.

*C. quadripunctata.* Shack, August.

*C. oculata.* Shack; Bog 3; Bog B, July to September. A very common species.

## Mecoptera

Members of this order were most numerous in the moist woods along Sphaerium and Argus Brooks. Bittacus in particular was extremely common there.

All determinations were checked over by Dr. R. C. Smith to whom grateful acknowledgement is made.

*Panorpa rufescens.* W. R.; Hook; S. Br.; B. Cr., July to September.

*P. maculosa.* Bog 2; S. Br., May 30 to July 15.

*P. subfurcata.* Hook; S. Br., May, June.

*P. nebulosa.* S. Br.; A. Br., June.

*P. latipennis.* A. Br., June.

*Merope tuber.* Shack, August 27. One female came to light.

*Bittacus strigosus.* S. Br.; W. R., July, August.

*B. pilicornis.* S. Br., July, August.

# TRICHOPTERA

## Rhyacophilidae

*Rhyacophila glaberrima* (?). One male, I. Br., July 28.

*R. sp.* Females only, S. Br., June.

*R. gordoni.* I. Br., September 5 to 23. A larva probably of this species was taken in the brook on September 12.

*Agapetus minutus.* Adults of this species emerged on Inlet Brook from September 13 to 23.

*Mystrophora americana.* Larvae and pupae of this species were taken on June 2 in Sphaerium Brook riffles while a pair of adults in copulo were taken on June 1. Fully grown larvae were still found on July 1 and 2. Young larvae were large enough to be conspicuous on July 28, and were common again in September when they were easily confused with Agapetus. Larvae were found also in Inlet Brook. Adults were caught on June 1, 12; and in the tent trap on August 14, 17, 18. A dark female specimen was taken at the Shack on August 28.

This species is the one reared by Lloyd and described under the genus Glossosoma. It was found by Dr. Betten that the male possessed the characters of Mystrophora so that name is here used.

## Hydroptilidae

I was able to collect seven species of this interesting family of minute forms and to rear three of these.

*Agraylea multipunctata.* This common European species has been reared by Siltala and described and figured with such detail that it is quite useless to redescribe the stages.

The larvae were very common in Mud Pond on the Potamogeton stems where they fed on algae and diatoms. On the ends of the cases were fastened several rows of Spirogyra filaments.

Adults began emerging on June 29, and continued until September 21 without a gap except from June 30 to July 27.

They are afternoon and twilight fliers rather than nocturnal forms. During cloudy afternoons in September they could be seen near the shores of the pond in large numbers, flying close to the water and frequently lighting on the surface.

*Polytrichia (Ithytrichia) confusa.* Two males, Shack, July 6 and 7.

*Hydroptila hamata* (?). Mud Pond, August 21.

*H. albicornis.* Shack, June 20 to September 14; Mud Pond, July 23 to August 25. This species appeared in great numbers in early July.

*H. consimilis* Morton. Shack, July 6 to 13; Mud Pond, July 7, August 23; I. Br., September 13.

*Hydroptila* females. Shack, July 29, August 5, 25.

*H. delineata.* Cases of this species were found to be very common on the rocks in the outflow from Grinophilus Springs and from similar springs near by. Adults emerged from August 7 to September 12. Pupae were still in the cages when they were taken up on September 21. Larvae were also present on the same day.

*Oxethira dualis.* Although the male genitalia agree with Morton's figure, the type of this species came from New Mexico.

The beautiful cases of larvae and pupae were common in Gyrinophilus Springs particularly in moss and algae. Adults emerged from August 20 to September 9.

### Philopotamidae

*Philopotamus distinctus.* A larva, probably of this species was taken in Inlet Brook on July 1. Adults were caught at the Shack, June 30 to August 20, and at I. Br., September 10, 14 and 15.

*Chimarrha aterrima.* The larva of this species were very common in the gravelly part of Sphaerium Brook. Larvae were collected on June 4, 6M July 1, 5, August 19; pupae on June 12, July 2, 28, August 15, and adults on May 31, June 12, July 1, 15, 22, August 11 to 22, August 31. During the period from August 14 to 22 inclusive, two hundred adults emerged in the tent trap covering a space of twelve square feet.

### Polycentropidae

*Phylocentropus lucidus* Hagen. The larval tubes were exceedingly abundant in the upper part of Sphaerium Brook and the lower part of Argus Brook. In many places the bulk of the tubes were equal to or greater than the surrounding mud. Tubes containing mature larvae and young pupae were collected along Argus Brook on June 19. Adults emerged in rearing cages on June 22, 23, 28 and July 1 and 4. Adults were also collected on Sphaerium and Inlet Brooks and at the Shack. Dates range from June 10 to August 22.

Dr. Betten has placed this species in a new manuscript genus because of a character in the wing venation. However, on the basis of larval structures and habits, it seems that this species should remain in the genus Phylocentropus.

*P. placidus.* Adults were taken only on Sphaerium Brook and on June 2, 12 and August 15 and 18.

*P. maximus* (?). One female, Sphaerium Brook, June 10.

*P. maculatus* (?). One female, Mud P., July 27.

*Plectronemia canadensis.* One male, S. Br., August 21; one female, Shack, July 8, August 7, 31.

*P. confusa* Hagen. One male, Mud P., September 20; one female, August 15.

*Holocentropus flavus.* Adults were taken at Mud P. and Shack from June 23 to July 10.

*H. sp.* Shack, July 7.

*Nyctiophylax vestitus.* Shack, June 20, 23, July 7, 8, 27, 29.

### Hydropsychidae

Larvae were common in the riffles of Sphaerium Brook.

*Hydropsychodes analis.* Adults were taken at the Hook, Shack, Mud P., I. Br. and S. Br. Dates of capture range from June 11 to September 12.

*H. sordida.* Shack, July 10, 22, 24, 29, August 7, 31.

*Arctopsyche (Arctopsychodes) apicalis.* One male, Shack, June 23.

*Diplectrona modesta.* Two males, Shack, June 22 and July 1; one female, Mud P., June 29.

*Hydropsyche alternans.* Shack, August 23, 25; Mud P., July 7, August 1, 10, 23; I. Br., September 12.

*H. phalerata.* Shack; Mud P.; I. Br.; S. Br., June 20 to September 12.

*H. recurvata.* Shack; Mud P.; S. Br., June 9 to August 21.

### Psychomyiidae

*Psychomyia flavida.* More specimens of this were taken than of any other two species together.

Eight hundred and ninety-three specimens were saved, four hundred and forty-two of which were caught at Mud Pond on the night of August 24. All specimens were caught at light either at the Shack or Mud Pond. Dates of capture range from June 20 to August 21. An interesting point is the fact that all of these specimens were females. The species was described from a female and Dr. Betten reports having seen only females. So it seems that this is another parthenogenettic species like Apatania muliebris in the Limnophilidae.

*Lype n. sp.* Adults were taken at S. Br., Mud P. and the Shack between June 11 and August 19. Although larvae were not found, they must live in the gravel riffles of S. Br. since adults were caught in the tent trap set there.

### Phryganeidae

The Phryganeidae were not studied in detail because of Lloyd's excellent work.

*Neuronia pardalis.* Reported by Lloyd from Argus Brook. Young larvae found there in July by us.

*N. postica.* Reported by Lloyd from streams in upland bogs. Adults emerge in May and June.

Our records—Pupal skin, Mud P., June 26; female, Shack, July 8.

*N. stygipes.* Reported by Lloyd from the headwaters of A. Br.; adults emerging during the last two weeks of May.

*Phryganea interrupta.* Pupal skins were found on Mud Pond from July 2 until August 5, indicating that the species emerges later in this region than in the marshes at the head of Cayuga Lake where Lloyd reared it.

*P. vestita.* Shack, August 31.

*Agrypnia glacialis* Hagen. One female, Mud P., September 1.

### Odontoceridae

*Psilotreta frontalis.* Larval and pupal cases were very common in the gravelly part of S. Br. Adults were taken from June 16 to 23.

### Leptoceridae

*Triaenodes injusta.* Females, Shack, July 8, August 7.

*T. marginata.* The larvae were common in the Chara and Potamogeton beds of Mud Pond. Adults emerged on July 6 to August 27. Most of the specimens were taken on the pond, but a few were taken at the Shack and one at Inlet Brook.

*Oecetis avara.* Adults were taken at the Shack on July 22 and August 21, and at the pond from July 25 to August 21.

*Œ. incerta.* Mud P., June 24, July 7 and 22; Shack, July 7, August 7, 23, 28.

*Setodes americana.* This species was taken at light only. Shack; Mud P., July 25 to August 9.

*Mystacides sepulchralis.* Larvae were found in Sphaerium Brook on June 2. A male was taken on Mud Pond, September 16. Larvae were rare in the brook.

*Leptocerus maculatus?* Females, Shack, July 24, 29, August 7.

### Molannidae

*Molanna blenda.* This species was previously reported from McLean by Lloyd, but was not reared. The larvae were very common on the sand and silt bars in Argus Brook and Inlet Brook and in the gravelly portion of Sphaerium Brook. In spite of the inconspicuous nature of the case, larvae could be quite easily detected, mainly because of their movement. However, pupal cases were very difficult to find because they were covered over with sand and silt.

Adults were taken from the 13th of August to the 16th of September.

### Calamoceratidae

*Ganonema americana.* This species whose larva has the unusual habit of boring into a dead twig and using it for a case, was first reared and described by Dr. J. T. Lloyd who reported it from both Michigan Hollow and McLean Bogs.

In the preserve we found the species to be more common in Sphaerium than in Argus Brook.

Adults were taken from June 18 to July 4.

### Sericostomatidae

*Brachycentrus nigrisoma.* No adults of this species were taken. However, large larvae were taken in Beaver Creek up near the springs on October 14, 1922, and small larvae on August 20, at the same place. Apparently the species does not occur within the preserve.

*Helicopsyche borealis.* The larvae of this well-known species were common in the gravelly part of Sphaerium Brook. Adults were taken from July to August 23, mostly on Sphaerium Brook.

*Olemira costalis.* Adults of this species were taken on Inlet Brook from September 9 to 21.

*Phanopsyche grisea.* Larvae of this species were found in Inlet and Argus Brooks. The species was reared for the first time last summer. One adult was taken on Argus Brook on August 27. A large series of specimens were taken on Inlet Brook from September 9 to 21. It was curious that this species while caught in large numbers at the water pan light on Inlet Brook, never strayed as far as the Shack.

*Mormyia vernalis.* One male and several females of this species were taken on the shore of Mud Pond, May 31, 1923.

*M. sp.* Adults were taken at the Shack on August 31 and September 5, and on Inlet Brook, September 13.

*Alepomyiodes wisconsinensis.* One male, Mud P., May 31, 1923.

*Goera calcarata.* One male, Mud P., June 24; one male, S. Br., July 15.

### Limnophilidae

Twenty-six species of this family are now recorded from the preserve and the majority of these have been reared.

*Neophylax autumnus.* Described in detail by Vorhies. Reported by Lloyd from Gyrinophilus Springs near headwaters of Beaver Creek. Found by us to be very abundant also in Inlet Brook. The larvae and prepupae were also found in Sphaerium Brook mingled with those of *N. concinnus.* Adults were reared from Inlet Brook on September 14, 17, 19 and 21.

*N. concinnus.* Reported by Lloyd as very abundant in Sphaerium Brook, adults emerging about the first week of October and continuing on the wing until the middle of November. The specimens I have referred to this species appeared as follows: S. Br., female, August 27; male September 3; reared male, September 6; Hook, male, September 3.

from Inlet Brook on September 14, 17, 19 and 21.

*Astenophylax argus.* This species was reared by J. T. Lloyd, and an excellent account of the life history is to be found in his paper, pages 57 to 60. Argus Brook was so named because of the abundance of this species there. We have very little to add to Lloyd's account. In 1924, the species was more common in Sphaerium Brook than in Argus. We also found a few specimens in Inlet Brook. Most of the adults appeared on June 12 and 13, but we took an adult on July 2 and another on July 8, showing that the species may emerge over a longer period than hitherto thought.

*Platycentropus maculipennis.* Lloyd reared this species and reported it as very abundant in Argus Brook and the upper part of Sphaerium Brook. In

addition we found it to be very common in Mud Pond where the larvae attached their cases to the root of the loose-strife clumps preparatory to pupation. The period of emergence is given by Lloyd as around the middle of July. We reared specimens from Mud Pond on July 21 and 24, but we also had them from Sphaerium Brook as late as August 16. Specimens were taken on Argus Brook, Sphaerium Brook and Mud Pond.

*Glyphotaelius hostilis.* Two partly grown larvae were found in Mud Pond, September 20. The adults are supposed to appear in April.

*Arctocia consocia.* This species was reported by Lloyd as emerging during the latter part of June. Our records range from July 28 to September 29. Localities were Inlet Brook, Sphaerium Brook and the Shack.

*Hesperophylax designatus.* One larvae was taken in Sphaerium Brook on September 10. This was reported as very common in the Big Springs in the McLean region, with adults appearing from early April to August.

*Limnophilus ornatus.* One female, Shack, June 19.

*L. pulchellus.* This species was first found at McLean on June 2, 1923, by the author. During the season of 1924 we found it at Mud Pond, Sphaerium Brook, Grass Bog 2 and the Shack. Dates of capture range from May 26 to June 16. The species was fairly common during this time.

*L. moestus.* One female, Shack, July 22.

*L. rhombicus.* Reported by Lloyd as common in the streams of the McLean region with adults on the wing from early June to the middle of August. Not taken by us during the past season.

*L. indivisus.* One male, Shack, August 23.

*L. sp.* (females). S. Br., September 14; Shack, September 23.

*L.* (*Rheophylax*) *submonilifer.* One male, Shack, June 18.

*Platyphylax lepidus.* This species was reared by us for the first time. Adults were taken at Mud Pond, Sphaerium Brook and the Shack. Reared specimens emerged on August 17 and 21. Dates of capture of the other specimens range from August 11 to September 21.

*Leptophylax gracilis.* This species was taken at light at the Shack from June 23 to July 22, the maximum number being taken on the first night.

*Allophylax punctatissimus.* One male, I. Br., September 9, and one male, A. Br., September 16.

*Halesus guttifer.* This species was as abundant as Stenophylax scabripennis in Sphaerium Brook. Reared specimens emerged from August 26 to September 17. The species was also taken at the Shack, Inlet Brook and Grass Bog 3. Dates range from August 26 to September 23.

*H. dan.* I. Br., September 11; Shack, September 13 to 23.

*Stenophylax gentilis.* Reared in Inlet Brook. Adults were taken in Inlet Brook from September 14 to September 20.

*S. limbatus.* One female, I. Br., September 9.

*S. scabripennis.* This species was reported by Lloyd as common in Sphaerium and Argus Brooks. The adults appearing in late August and early September.

We found them also very common in Inlet Brook. Our records for adults range from July 11 to September 21. Adults were taken at the Shack, Mud Pond, Inlet Brook and Sphaerium Brook. On Sphaerium Brook most adults appeared between August 13 and 26; on Inlet Brook, September 9 and 13.

*S. sp.* Reared from Sphaerium Brook, September 5 and 8. Taken on Inlet Brook, September 9, 13, 21.

*Chilostigma difficile.* This species was reared by Lloyd who reported larvae only from a limited area of Argus Brook. We found larvae also in Inlet Brook. This is a fall species. We have taken adults between the dates of October 16 and December 2.

*C. pallidum.* One male, taken November 11, 1922, agrees with the color description. Another male taken November 15, 1924, has same genitalia as above, but the wings are more heavily pigmented. Also a female was taken on the same date.

# LEPIDOPTERA

Listed by W. T. M. Forbes

As no biological work has been done on the Lepidoptera of the McLean Reservation, the following report is merely a list of the forms known to occur on the bogs and in their vicinity; with dates of occurrence and a few notes aimed at making the list more available as a basis for future study.

The material may be divided in two parts. For a long time students and others have collected at and about the bogs. This material was as a rule merely labelled "McLean," with the date, and is entered in the list only when there are no specimens with completer data. Part of these were no doubt taken at some distance from the bogs, though it has been the custom to use a special label for the Chicago Bogs, and this material has been omitted. The rest was taken by the group stationed on the bogs the last two summers and has record of station and date. Most of the early collecting was done in the spring and fall and by day, while the major part of that of the summer of 1924 was done in midsummer and at night, so that the two lots supplement each other.

Species peculiar to the bogs, or only known hereabouts at a few other stations, are marked with an asterisk.

### *Suborder* Jugatae

#### *Family Hepialidae*

*Sthenopis auratus.* July 14, 1919. A very rare species which has also been taken once at Ithaca.

### *Suborder* Frenatae

#### *Family Incurvariidae*

*Paraclemensia acerifoliella* (Maple Case-bearer).

#### *Family Eucleidae*

*Tortricidia flexuosa.* Shack, July.
*T. pallida flavula.* Shack, July.
*T. testacea.* May 30, 1918 (Forbes).
*Lithacodes fasciola.* Hook, July 23.
*Packardia elegans.* Shack, July.

#### *Family Tineidae*

*Scardia approximatella.* Shack, August 23.
*Tinea obscuristrigella.* Shack, August 7.
*T. auropulvella.* Shack, July to August.

*T. acapnopennella.* Shack, July. Too poor for complete certainty.
*Monopis biflavimaculella.* Shack, June to August.
*Xylesthia pruniramiella.* Shack, July 29.
*Xylesthis pruniramiella.* Shack, July 29.

*Family Tischeriidae*

*Tischeria solidaginifoliella.* Shack, August 8.

*Family Lyonetiidae*

*Bucculatrix sp?* Shack, July. Two species of this difficult genus, one of them possibly a light variety of *B. erransella.*

*Family Opostegidae*

*Opostega albogalleriella.* Shack, August.
*O. quadristrigella.* Shack, July 30. These Opostegas should be reared to find out whether they are really different species.

*Family Gracilariidae*

*Gracilaria rhoifoliella.* Shack, June, August.
*G. burgessiella.* Shack, August.
*G. elongella.* October 18, 1919 (Forbes). This species was very common at that time. It has hardly ever been taken in the east, though well known from the west and Europe. Most of the specimens were the typical red form. Two specimens were also taken July 30 to August, which may be one of the numerous varieties of this species.
*Parornix sp?* Shack. It is impossible to name moths of this genus without rearing.
*Acrocercops strigosa.* Shack, June, August 28. A curious form which appears to belong to this species.
*Parectopa pennsylvaniella.* Shack, August.
*Parectopa sp?* Shack, June.

*Family Coleophoridae*

*Coleophora leucochrysella.* Shack, August 20 (determination not quite certain).
*C. coruscipennella.* Shack, July.
*C. vernoniaeella.* Shack, June.

*Family Cycnodiidae (Elachistidae)*

*Aphelosetia orestella* (formerly placed in Elachista). Shack, July to August.

### *Family Oecophoridae*

*Eumeyrickia trimaculella*. Shack, August.

*Cryptolechia tentoriferella*. Shack, September.

*Gerdana caritella*. Shack, July to August. Besides the typical solidly yellow form of this species a couple of specimens were taken with the thorax and base of the fore wing contrasting dark brown.

*Psilocorsis reflexella*. Shack, July.

*Depressaria atrodorsella*. Shack, June 18.

**D. lythrella*. August. Shack; H. R. Not bred, but compared with one of Walsingham's paratypes. The only record for the vicinity of Ithaca.

*D. pulvipennella*. Shack, September.

*D. symmochlota*. August 20, 1925.

*D. allenella*. July to August. Shack; Mud P. Formerly placed in Semioscopis.

*Epicallima argenticinctella*. Shack, August 22.

*Borkhausenia ascriptella*. Shack, August.

### *Family Xylorictidae (Stenomidae)*

*Stenoma schlaegeri*. Shack, June 22.

*S. algidella*. Shack, July 5.

### *Family Gelechiidae*

*Gelechia mediofuscella*. June. Shack; A. Br.

*Gelechia*. New species near *G. trialbamaculella*. June. Bog A; S. Br.

*Gnorimoschema gallaesolidaginis*. Shack, August 28.

*G. banksiella*. Shack, July 17.

*Anacampsis agrimoniella*. Mud P., September 20.

*Trichotaphe juncidella*. June to July. Shack.

*Dichomeris punctidiscellus*. S. Br., June 21.

*D. ligulellus* (the Palmer-worm). SE. Sl., August.

*Anorthosia pulvipennella*. Shack, July to August.

*Duvita* (Battaristis) *conclusella*. Shack, August.

*Telphusa sp?* Shack, July 28 to August. Apparently *T. querciella*.

*Glauce pectenalaeella*. Shack, July 22, August 6, 7. These specimens are the same northern race I have taken at Rock City in the western part of the state. The pattern is apparently normal and secondary sexual characters wholly normal, but vein R is separate from M1. in both wings, a character which is almost invariably of generic value.

*Aristotelia roseosuffusella*. Shack, July.

*Aristotelia sp?* Shack, July to August 8. One of the several undescribed species in the pudibundella group.

*Epithectis attributella.* Shack, August.

*Evippe prunifoliella.* Shack, July 24. A strikingly marked specimen which may prove to be a distinct local form.

*Metzneria lappella* (the Burdock Moth). Shack, July to August.

*Family Blastobasidae*

Five or more species of this family were taken, mostly of the genus Holcocera. They are quite beyond my power to name.

*Family Lavernidae*

*Limnoecia phragmitella.* Abundant in cat-tail heads.

*Perimede erransella.* Shack, July 13.

*Psacaphora terminella.* May 30, 1918 (Forbes).

*Cosmopteryx fernaldella.* Shack, July. A series of this species, which is no doubt a feeder on marsh grasses or sedges, and has not been taken elsewhere in the vicinity.

*Family Yponomeutidae*

*Plutella maculipennis* (Diamond-back Moth). Shack, August.

*Cerostoma dentiferella,* form *canariella.* Shack, August 1, 1925. A giant yellow Tineid with hooked wings. This is the first record of this striking moth in the east.

*Argyresthia oreasella.* July 30 to August. Shack; Bog A; A. Br.

*Family Glyphipterygidae*

*Glyphipteryx impigritella.* H. R., August 31, 1925.

*Family Heliodinidae*

*Schreckensteinia festaliella.* Shack, July 11.

*Family Aegeriidae*

*Conopia exitiosa* var. *edwardsii.* Bog 3, September 3. This is the two-banded form of the female peach tree borer, which seems commoner than the type in this vicinity.

*Family Tortricidae*

*Subfamily Eucosminae*

*Hemimene dana.* May 30, 1918 (Forbes).

*Laspeyresia interstinctana* (Clover-seed Caterpillar). A. Br., September 29.

*Melissopus latiferreanus orichalceanus.* B. Cr., September 20.

*Epinotia lindana.* I. Br., September 21.

*E. signatana.* May 30, 1918 (Forbes).

**E. medioviridana.* August to September. Shack; I. Br.; H. R. These are the only captures in New York for this very rare species.

*E. vertumnana.* May 25, 1912.

*E. transmissana.* Shack; W. R.; Bog 1; Hook. Abundant.

*E. rectiplicana.* June. Bog B; Shack; S. Br. A species that has been generally considered confined to the west, but occurs at several places in New York.

**Ancylis tineana.* W. R., June 18.

*A. cornifoliana.* S. Br., June 12.

*A. divisana.* May 30, 1918 (Forbes).

*Anchylopera nubeculana.* June to July. Shack; A. Br.; Mud P.; Hook; W. R.

*A. burgessiana.* June to July. Shack; W. R.

*A. fuscociliana.* June. Hook; S. Br.; A. Br. These forms must be reared from their various foods. They seem to intergrade, but too little is known of their life-histories.

*A. angulifasciana.* Shack, August 31.

*A. discigerana* (?). Shack, July 18. This is the gray species that Heinrich calls spiraeifoliana. Discigerana seems the safest name. We know far too little either of its distribution or life history.

*Epiblema obfuscana.* Shack, June.

*E. scudderiana.* Shack, June 24.

**Eucosma cataclystiana.* Shack, June to July. Abundant. A characteristic and very queer swamp species, whose life history should be of interest.

*E. juncticiliana.* Shack, July 30.

*E. dorsisignatana.* Shack, August 25.

*E. similana.* Shack, August to September. This is the form that is often called confluana. Breeding may be necessary to determine if it is different from dorsisignatana, also the distribution does not seem to be quite the same.

*E. womonana.* Shack, August 26. The only other specimen I have seen from New York was taken at Ithaca, also in 1924.

*Thiodia refusana.* June. A. Br.; Bog 3. Female only and determination therefore a little doubtful.

*T. formosana.* May 30, 1918.

*T. radiatana.* Shack, June.

*T. ferruginana.* S. Br., June 13.

*T. sp?* A few specimens have been taken which are either awemeana or roseoterminana, if these are really distinct species.

*T. olivaceana.* June. Shack; S. Br.

*Gretchina amatana.* May 30, 1918 (Forbes). Abundant on tree trunks with *E. signatana.*

**G. semialba.* A very striking thing with white hind wing.

*Exentera maracana.* May 14, 1919 (Forbes).

*Gypsonoma fasciolana.* May 30, 1918 (Forbes).

*Olethreutes bipartitana.* Bog A; Bog 2; Shack; W. R.; Hook, June to August.

*O. constellatana.* June. Bog A; Hook.

*O. instrutana.* Shack, August 25.

*O. nimbatana.* Shack, July 8.

*O. campestrana.* June to July. Shack; Hook; S. Br.

*O. hebesana.* Shack, September 13.

*O. fuscalbana.* June. Shack; H. R.; W. R.

*O. impudens.* Shack, July to August.

*O. deceptana.* Shack, August 7.

*Cymolomia fasciatana.* July. Shack; A. Br.

*C. cincinnana.* Shack, July 23.

*Cymolomia tenebrica.* Three specimens, July 15 to 23. Bog 3; A. Br.; W. R. Known only from this Reservation.

**Cymolomia sp?* A single female of a deep brown undescribed species. Mud P., August 23.

*Polychrosis sp?* Hook, June 25. Probably *P. carduana;* but it is not safe to determine in this genus save from reared specimens.

### *Subfamily Tortricinae*

*Sparganothis xanthoides.* July to August. Shack; W. R. Both orange and brown forms were taken.

*S. reticulatana.* H. R., August.

*S. violaceana.* Bog A, August 4; S. Br., June 21.

*S. sulfureana.* Shack, July, September.

*S. idaeusalis.* Shack, July.

*Amorbia humerosana.* May (Forbes).

*Coelostathma discopunctanum.* July to August. Shack; Hook; W. R.

**Peronea minuta,* form *cinderella.* Abundant on the round bogs in late fall. The larvae is well known on cranberry. Apparently the species is single brooded at McLean, as not a single specimen of the yellow summer form was taken.

*P. angusana.* October 18, 1919. Busck considers this a variety of *P. variana,* which is an entirely different thing superficially. It is at least a good local form.

*Peronea.* Several undetermined species have been taken on the reservation, at least two of them undescribed.

*Cnephasia peritana.* Shack; W. R.; Bog 2, July.

*Tortrix clemensiana.* Shack, June to July.

*T. pallorana.* Shack, late June, late September.

*Archips purpurana.* Shack, July 29 to August.

*A. cerasivorana.* Shack, July 31 to August.

*A. mortuana*. Shack. July 11. This is probably a dark variety of semiferana, rather than of argyrospila.

*A. melaleucana*. June. Shack; Hook; W. R. Abundant.

*A. obsoletana*. Shack, July 28 to August. This is more or less definitely a swamp species, though not rare elsewhere.

*Pandemis lamprosana*. August. Shack; Hook; A. Br.

*P. limitana*. August. Shack; H. R.

### *Family Phaloniidae*

*Hysterosia cartwrightiana*. Shack, July 4.

*H. baracana*. Shack, July to August. This species shows a good deal of variation.

*Phalonia angulatana*. July, September 17. Shack; S. Br.

*P. biscana*. Shack, August 23. The typical dark form.

**P. ednana*. Shack, July 25; W. R., July 25. A new genus is needed for this curious form, which is not only not a true Phalonia, but may not be even a Phaloniid.

*P. atomosana*. Shack, August 29, September 23.

### *Family Pyralididae*

#### *Subfamily Schoenobiinae*

**Schoenobius melinellus*. July to August. Bog 1; Shack.

**S. longirostrellus*. Hook, July 23. These are characteristic grass-swamp species, and no doubt are borers in coarse grass-like plants.

#### *Subfamily Chrysauginae*

*Galasa nigrinodis*. Shack, July 24 to August 26. This often goes under the name of rubidana, a related tropical species.

*Polloccia alticolalis*. August. A. Br.; H. R.

#### *Subfamily Galleriinae*

*Paralispa terrenella*. Shack, June 23.

#### *Subfamily Glaphyriinae*

*Lipocosma fuliginosalis*. Shack, July to August.

#### *Subfamily Pyraustinae*

*Desmia funeralis*. Shack, July 7.

*Evergestis straminalis*. June to August. Shack; I. Br.; A. Br.; S. Br. Abundant.

*Loxostege obliteralis.* May 30, 1918 (Forbes).

*Nomophila noctuella.* August to September. Bog A; Bog 3.

*Sameodes adipaloides.* May 14, 1919 (Forbes).

**Phlyctaenia acutella.* Shack, July 6. There are a few old specimens in the Cornell collection with an Ithaca label, but I suspect they may have come from McLean, as they are from student collecting.

*P. terrealis.* Shack, July 8.

*P. extricalis.* Shack, July 5, 6.

*P. helvalis.* Shack, July 7.

*P. tertialis.* June to July. Shack; Bog A; S. Br.; A. Br. One of the specimens is a pale aberration in which all the broad brown shades are absent, and the pattern is formed of fine lines.

*Cindaphia bicoloralis.* H. R., August 25.

*Pyrausta fissalis.* July to August. Bog A; Bog 1; Shack; A. Br.; S. Br.; W. R.; SE. Sl. There may be more than one species in the material that passes under this name, but there seems to be no difference of structure and only rearing from known foods can settle the matter.

*P. aeglealis.* Shack, August 10.

*P. acrionalis.* Shack, August.

*P. unifascialis subolivalis.* Shack, June to July.

*P. funebris.* June. Hook; S. Br.; Bog 2.

### *Subfamily Nymphulinae*

*Nymphula icciusalis.* July. Shack; Mud P.

*N. badiusalis.* Bog A, September 7. These species breed only in open water, but are rather wide rangers in flight.

*Geshna primordialis.* July. A. Br.; Hook. This is probably not an aquatic, though oftenest flying near water.

### *Subfamily Scopariinae*

*Scoparia penumbralis.* May 30, 1918 (Forbes).

*S. basalis.* July to September. Shack; W. R.; S. Br.

*S. lugubralis* (?). W. R., July 25. With only one female the determination is uncertain; but if not lugubralis the species is new. The general distribution of lugubralis is northern.

### *Subfamily Crambinae*

*Argyria nivalis.* Shack, August 17.

*A. critica.* Shack, July 29, 30. It appears this species is at least as common as the better known *A. auratella;* while the differences are not large I have not yet seen an intermediate.

*A. auratella.* Bog A, July 18.

*Crambus girardellus.* Shack, July to August.

*C. pascuellus floridus.* Shack, July.

**C. bidens.* Bog A, August 12. I have only one other record from the state, Niagara Falls. The species is well known in New England, where it seems to be limited to peat-bogs.

*C. praefectellus.* Shack, August to September.

*C. alboclavellus.* Shack, July.

*C. agitatellus.* July. Bog A; Bog 1; Shack.

*C. laqueatellus.* June to July 8. Bog A; Shack; H. R.

*C. hortuellus.* July. Bog 1; Bog 2; Shack.

*C. albellus.* July to August. Shack; S. Br.

*C. turbatellus.* Shack, July 25. A rare species which I have only taken in wet places.

*C. elegans.* Shack, August.

*C. polingi.* Shack, July 10. A rare species in the east. My only other New York specimens are from Ithaca.

*C. vulgivagellus.* August. Shack; Bog A.

*C. mutabilis.* Shack, July.

*C. trisectus.* Shack, July.

*C. ruricolellus.* August. Shack; Bog 3; W. R.; A. Br.; H. R. Abundant.

*C. luteolellus.* Shack, June to August. All the varieties are represented; *C. caliginosellus, C. zeellus* and several unnamed ones as well as the typical yellow form which was commonest. In all other places where I have collected, dark forms (*C. caliginosellus, C. zeellus*) have dominated over the yellow one.

**Raphiptera argillaceella.* This little falcate winged Crambid is abundant on the round bogs, but difficult to catch as it keeps low among the bushes as a rule. My dates are August to September and the end of May.

### *Subfamily Phycitinae*

*Acrobasis sp.* Several specimens of a form related to *A. latifasciella.* Determination is uncertain without the food habits. Shack, July to August.

*Nephopteryx ovalis.* Shack, July 23.

*Meroptera pravella.* Shack, July 7.

*Euzophera semifuneralis.* Shack, August 11.

*E. ochrifrontella.* Shack, July 22, August 20.

*Vitula edmandsii.* Shack, July 9.

*Canarsia ulmiarrosorella.* Shack, July 10.

*Moodna ostrinella.* Shack, August.

*Ephestiodes sp.* Shack, August 4. This undescribed species is also not rare at Ithaca.

### *Subfamily Anerastiinae*

*Peoria haematella.* Shack, July to August. Common, but only at the Shack.

*Family Pterophoridae*

*Platyptilia pallidactyla.* Shack, July. May 30, 1918.

*Oidaematophorus eupatorii.* Shack, August 21, September 1.

*O. kellicottii.* Shack, June 22.

*O. elliottii.* Shack, June 28 (determination not quite sure).

*O. monodactylus.* Shack, August.

*Family Saturniidae*

*Automeris io.* Shack, May 31, July.

*Tropaea luna.* Seen at the Shack (Sibley).

*Telea polyphemus.* July.

*Family Lasiocampidae*

*Malacosoma americana* (Tent Caterpillar). Imago: Shack, July.

*M. disstria* (Forest Tent Caterpillar). Shack, July.

*Family Drepanidae*

*Eudeilinea herminiata.* June, August. Shack; Bog 3; W. R.; S. Br.; Mud P.; H. R.

*Drepana arcuata,* form *genicula.* H. R., May to June.

*Oreta rosea.* Shack, September 5.

*Family Geometridae*

*Subfamily Hemitheinae (Geometrinae)*

*Nemoria mimosaria.* May 31, 1913.

*Mesothea incertata.* Bog B, June 18.

*Chlorochlamys chloroleucaria.* Shack, June 23, August 23.

*Subfamily Sterrhinae*

*Sterrha ennucleata.* Shack, July to August. This and the following species have been passed about between a variety of genera, the names most used being Acidalia, Synelys, Leptomeris and Eois. Both varieties were taken as well as the type form.

*S. quadrilinearia.* Shack, July.

*S. junctaria.* Shack, July. It is not clear if these two are really distinct species or not.

*S. inductata.* Shack, June, August.

*Haematopis grataria.* Shack, August 31.

*Subfamily Larentiinae (Hydriomeninae)*

*Trichodezia albovittata.* June, August. Shack; Hook; I. Br.; SE. Sl.; W. R.; Bog 1.

*Lobophora nivigerata.* Hook, June 11.

*Heterophleps triguttaria.* June to August. Shack; A. Br.; I. Br.; W. R.

*Calocalpe undulata.* June to July. Shack; A. Br.; S. Br.

*Lygris testata.* Shack, August 26 to September 19.

*L. truncata.* August 26, September 20. Shack; B. Cr.

*Dysstroma hersiliata.* June 30, 1921.

*D. truncata.* Shack, August 29, 1925.

*Hydriomena pluviata.* May.

*H. renunciata.* June to July 1. Shack; Hook; A. Br.; S. Br.; H. R.

*H. ruberata.* Shack, June.

*Xanthorhoë designata.* July 25 to August. Shack; W. R.; H. R.; SE. Sl.

*X. ferrugata.* June, August. Shack; H. R.

*X. lacustrata.* June to July. Shack; Hook.

*X. intermediata.* May, August. H. R. Packard got these two names interchanged, and many have followed him since.

*Orthonama obstipata.* Shack, July to August. The strong sexual variation and enormous range of this species has caused it to accumulate a great variety of names. *Percnoptilota fluviata* is most familiar in this country.

*O. centrostrigaria.* Shack, August.

*Spargania magnoliata.* August. Shack; H. R.

*Euphyia multiferata.* Shack, June 26.

*Mesoleuca ruficiliata.* August. Shack; Hook; A. Br.; W. R.; I. Br.

*Epirrhoe sociata.* May 31, 1913. Barnes and McDunnough call this *E. alternata,* which may be correct, but is certainly unfamiliar.

*Eulype hastata gothicata.* June, Hook; A. Br.

*Hydrelia lucata.* June. Shack; Mud P.; W. R.

*H. inornata.* June. Shack; S. Br.; Hook; Bog 3.

*H. albifera.* June, September. Shack; H. R.; Mud P.; W. R.

*Eudule mendica.* July. Shack; Bog A; SE. Sl.

**Eupithecia strattonata.* Shack, June 24. The only regional record for this species, easily recognized by the chocolate brown under side.

*E. latipennis.* Shack, July 6. A little too poor for certainty in this very difficult genus.

*Horisme intestinata.* Shack, July.

### *Subfamily Geometrinae (Ennominae)*

**Epelis truncataria.* Bog A, June. A characteristic acid-heath species, which in the Ithaca region seems to be limited to these bogs.

**Eufidonia notataria.* June, general. Another acid-soil species, but less strictly confined.

*Orthofidonia exornata.* May 30, 1918 (Forbes).

*Bapta semiclarata.* June. Shack; A. Br.; Mud P.

*B. vestaliata.* June. Shack; Mud P.

**B. glomeraria.* May 6, 1916.

*Physostegania pustularia.* Shack, July to August.

*Gueneria basiaria.* June to July 7. Shack; S. Br.; W. R.

*Cabera variolaria.* June to July. Shack; H. R.

*C. erythremaria.* Shack, June to August.

*Sciagraphia granitata.* June to July. Shack; Hook; A. Br. There may be more than one species in this heterogeneous lot.

*S. mellistrigata.* Shack, June (rare).

*Philobia aemulataria.* July. Shack; SE. Sl.

*Itame ribearia.* Shack, July 31.

*I. exauspicata.* Late July. Shack; Hook; W. R. This species has gone long as bicolorata, and also has stood (especially western specimens) as *I. subfalcata.*

*Homochlodes frittillaria.* Shack, June.

**Lithina detersata.* Shack; Hook; S. Br. Abundant locally. This genus, better known in America as Apaecasia, is characteristic of more or less acid swamps.

**L. subaequaria.* June to August 8. Shack; Bog 1; Bog 3. Better known as defluata.

*Caripeta divisata.* July. Bog A; Hook.

*Paraphia unipunctaria.* W. R., July 25.

*Anacamptodes ephyraria.* Shack, August.

*Melanolophia canadaria.* June. Shack; Hook.

*Æthaloptera anticaria.* W. R., June 19.

*Ectropis crepuscularia.* June to August. Shack; A. Br.

*Sicya macularia.* July 11, 1925.

*Therina fiscellaria.* S. Br., September 20.

*Campaea perlata.* Shack, August.

*Eugonobapta nivosarium.* July. Shack; A. Br.

*Ennomos subsignarius.* W. R., August.

*Xanthotype crocataria.* July. Shack; S. Br.; B. Cr.; Bog A.

*Plagodis serinaria.* May 30, 1918 (Forbes).

*P. phlogosaria.* Shack, July 29. A specimen with olive ground color.

*Hyperitis amicaria.* June. Shack; SE. Sl.; A. Br.; S. Br.; Hook.

*Nematocampa filamentaria.* Shack, July to August. In some unaccountable way Hulst attached to this species the name of Ania limbata, originally proposed for the female of a British geometer of quite another genus.

**Metarrhanthis obfirmaria.* May 29, 1915. An acid heath species.

*M. hypochraria.* June to July. Shack; Bog B; W. R.; Hook; SE. Sl. Both pale and dark forms are found on the reservation.

*Euchlaena obtusaria.* Shack, July 8.

*E. johnsonaria.* July 11, 1925.

*Priocycla armataria.* Shack, June to July.

*Tetracis crocallata.* Shack, June 22.

*T. lorata.* Shack, June.

*Sabulodes transversata.* August 31 to September. Shack; Bog 2; A. Br.; H. R.

*Family Sphingidae*

*Paonias excaecatus.* Shack, July.

*Smerinthus geminatus.* May 30, 1918 (Forbes).

*Hemaris thysbe.* Bog A, June 18, August.

*Family Notodontidae*

*Datana angusii.* Shack, July 7.

*D. ministra.* July.

*Notodonta basistriens.* Shack, August 3.

*Nadata gibbosa.* Shack, July 5.

*Nerice bidentata.* Shack, July 9.

*Symmerista albifrons.* Shack, July.

*Schizura leptinoides.* July 9, 1921. A female.

*S. unicornis.* August. Shack; H. R.

*Family Liparidae*

*Notolophus antiqua* (Black-headed Tussock). Bog C, August 20.

*Hemerocampa definita* (Yellow-headed Tussock). Shack, September 4. It is curious that both of the relatively rare tussock moths turned up at McLean, while the abundant H. leucostigma was not taken at all. At Ithaca this year (1924) it appeared in normal numbers.

*Family Noctuidae*

*Subfamily Hypeninae*

*Plathypena scabra.* 1925.

*Parahypenodes quadralis.* Shack, July 30. This is the second record for the state, and so far as I know the second specimen that has been taken aside from the type.

**Lomanaltes eductalis.* August to early September. Shack; I. Br. Apparently a swamp species.

*Bomolocha deceptalis.* W. R., July 25.

**Capis curvata.* July to August 7. Shack; A. Br. This is the only case I have known of several specimens of this species being taken together.

*Rivula propinqualis.* June to August. Shack; W. R. A common and general swamp species.

*Pangrapta decoralis.* May 30, 1918 (Forbes).

### *Subfamily Herminiinae*

*Palthis angulalis.* S. Br., May, June 23.

*Lascoria ambigualis.* Shack, June 13 to August.

*Bleptina caradrinalis.* Shack, August 8.

*Phalaenophana pyramusalis.* Shack, June 16 to July.

*Renia factiosalis.* July 30 to August. Bog A; Shack; S. Br.; H. R.

*R. flavipunctalis.* August. Shack; W. R.

**Chytolita petrealis.* Mud P., June 24. A characteristic northern species that only narrowly overlaps with morbidalis, the common form of this region.

*C. morbidalis.* June to July. Shack; Mud P.

*Philometra metonalis.* July. Shack; W. R.; S. Br.; A. Br.; Bog 1.

*Hormisa absorptalis.* July to August. Shack; Bog A; S. Br.

*Zanclognatha inconspicualis.* Shack, July 25, August 4.

*Z. cruralis.* Shack, July 12, 25. At Ithaca cruralis flies in June, being earlier than *Z. ochreipennis.* Locally it is paler than *Z. pedipilalis,* not darker as Smith states; but may be distinguished by the different course of the outer line, and the lack of sex-scaling on the under side.

*Z. ochreipennis.* Shack, July to August. McLean specimens show the usual wide variation in color. Easily distinguished from cruralis by the waved transverse lines, from marcidilinea (which is not rare at Ithaca) by the dark subterminal shade.

*Z. laevigata.* July to August. Shack; W. R.; S. Br.

*Z. lituralis.* Shack, June to August.

*Epizeuxis americalis.* July.

*Pseudaglossa rotundalis.* Shack, August.

*P. lubricalis.* Shack, July to August.

*P. scobialis.* Shack, July 23 to August.

*Dyspyralis illocata.* Shack, July. The year 1924 was humid all summer and so was a very good year for the Herminiinae, which are mostly feeders on damp, dead leaves. In a normal year far fewer would probably be taken.

### *Subfamily Erebinae (Noctuinae)*

*Scoliopteryx libatrix.* Shack, July 30, August 8.

*Calpe canadensis.* Shack, July 25.

*Panapoda rufimargo.* Shack, July 25.

This, which is the principal group of Noctuidae in the tropics, is even more poorly represented at McLean than at Ithaca. Only one of these three species is really a proper member of the subfamily. Calpe and Scoliopteryx both in structure and range might better find a place in the Hypeninae.

### *Subfamily Plusiinae*

*Abrostola urentis.* Shack, July to August.

*Plusia aereoides.* Shack, July 31.

*P. ampla.* Shack, July 11.

*P. falcifera.* June, August. Bog A; Bog B; Bog 1; Bog 3; B. Cr. This form feeds freely by day, and so was taken at other places than the Shack.

*Subfamily Catocalinae*

*Zale horrida.* Shack, June to July.

*Caenurgia crassiuscula.* June, August. Shack; H. R. Abundant generally. In the whole Ithaca region crassiuscula is far more abundant than erechtea.

*Parallelia bistriaris.* Shack, July.

*Catocala ultronia.* Shack, August 28.

*Subfamily Erastriinae*

*Tarachidia candefacta.* Shack, August.

*Lithacodia muscosula.* S. Br., July 28.

*L. apicosa.* Shack, June 21.

*L. carneola.* Shack, July to August.

**L. bellicula.* Bog A, June 26, July 2. A definite swamp species, but I think not strictly confined to peat bogs.

*L. albidula.* June to August. Shack; Bog A; Bog 1; Bog 2.

*Subfamily Acronyctinae*

*Eudryas unio.* Shack, July to August. The larva eats swamp loose-strife.

*Amolita fessa.* Shack, July 22.

*Enargia paleacea.* A. Br., September 16.

*Achatodes zeae.* August 25. Shack; H. R.

*Apamea nictitans.* Shack, July to August.

*A. velata.* Shack, August 7.

*Menopsimus caducus.* June 23 to August. Shack; H. R.

*Proxenus miranda.* Shack, June, August to September 4.

*Chutapha periculosa.* H. R., August.

*Form v-brunneum.* August. Shack; A. Br.

*Brotolomia iris.* Shack, June 26, July 10.

*Apatela dactylina.* Shack, July 25.

*Sidemia devastatrix.* August. Shack; Bog A. The specimen from the round bog was presumably a stray, as there is nothing about the larval habits to adapt it to wet conditions.

**Eremobia leucoscelis.* Shack, August 30. The only capture in this region.

*Agroperina helva.* Shack, August 20.

*A. dubitans.* August to September. Shack; A. Br.; H. R.

*Euplexia lucipara.* Shack, July 10.

**Trachea enigra.* Shack, July 10. I have compared the specimen with

authentic material in the National Museum from Alberta and it is certainly this species. It is my only record for the state, and the first published record for the east. The form is probably mistaken as a rule for a poor specimen of S. devastatrix.

*T. impulsa.* Shack, July 6.

*T. finitima.* Shack, June to July.

*Septis arctica.* Shack, July to August 7.

*S. vultuosa.* Shack, June 30 to July.

*S. lignicolor.* Shack, July.

*S. nigrior.* Shack, July.

*Amphipyra pyramidoides.* Shack, August to September.

### *Subfamily Cuculliinae*

*Amathes ralla.* Shack, September.

*A. puta.* Shack, September 21. I am convinced this is merely a brown form of *A. ralla,* but if so it must be in part a local form as it is much rarer than *A. ralla* in the vicinity of Ithaca, while elsewhere it is commoner than *ralla.*

*Graptolitha innominata.* Shack, September 16. A typical specimen.

**Lithomoia germana.* Shack, September 13.

*Cucullia intermedia.* Shack, September 6.

### *Subfamily Hadeninae (Mamestrinae)*

*Leucania pallens luteopallens.* Shack, June 24 to July.

*Cirphis insueta.* Shack, July.

*C. phragmitidicola.* Shack, June 24, August 26.

*C. unipuncta.* Shack, August 7.

*C. pseudargyria.* Shack, August 7.

*Morrisonia confusa.* Shack, June 6.

*Nephelodes minians.* September. Shack; B. Cr. The specimens run very dark.

*Eriopyga furfurata.* Shack, July 22.

*E. cynica.* Shack, June 27 to July.

*E. oviduca.* Shack, June to July.

*Chabuata signata.* July to September. Shack; H. R.

*Polia lorea.* Shack, July. I call this genus Polia, following Hampson, and Barnes and McDunnough. It is better known as Mamestra.

*P. renigera.* July to September. Shack; H. R.

**P. goodelli.* Shack, June 24 to August 6.

*P. grandis.* Shack, July 1, 6.

*P. meditata.* August. Shack; H. R.

*P. imbrifera.* Shack, July.

*P. detracta.* Shack, July.

### *Subfamily Agrotinae*

*Eueretagrotis sigmoides.* Shack, July 22.

*E. perattenta.* Shack, July 22.

*Noctua haruspica.* July to August.

*N. clandestina.* July, September 21. Shack; A. Br.

*N. plecta.* Shack, July 11.

*N. jucunda.* Shack, July 10, 24. A very rare species, apparently of northern distribution.

*N. bicarnea.* August. Shack; H. R.

*N. normanniana.* Shack, August.

*N. baja smithii.* August. Shack; H. R.

*Feltia ducens.* August. Shack; H. R. This is the brightly marked thing that passes very frequently for *F. subgothica.*

*F. jaculifera.* Shack, July 31, August 12.

*Form herelis.* Shack, July 25.

*F. volubilis.* Shack, June 24.

*F. venerabilis.* Shack, September 21.

### *Family Arctiidae*

*Haploa confusa.* Shack, July 22.

*Apantesis virgo.* July 11, 1925.

*A. parthenice.* Shack, August 21, 1925.

*A. phalerata.* June. Shack; H. R.

*A. nais.* Shack, July. The hind wing varies from red to yellow.

*Estigmene congrua.* Shack, June.

*E. acraea.* Shack, June 25.

*Hyphantria textor.* Shack, June.

*Isia isabella.* Shack, July.

*Spilosoma virginica* (Yellow Bear). Shack, July 1.

*S. latipennis.* Shack, June to July 3. This is the only place I have ever known where *S. latipennis* is commoner than *S. virginica;* it is usually many times rarer.

*Eubaphe immaculata.* June, August 31. Shack; H. R. These specimens, as generally around Ithaca, are somewhat intermediate between *E. immaculata* and typical *E. aurantiaca.*

*Halysidota tessellaris.* Shack, July to August 6.

*H. caryae.* Shack, June 30 to July.

### *Family Lithosiidae*

*Hypoprepia fucosa.* Mud P., August 20.

*Crambidia pallida.* Shack, August 12.

### *Family Nolidae*

*Roeselia cilicoides.* Shack, July to August, 1925.

### *Family Euchromiidae (Syntomidae)*

Hampson has shown that the name Syntomidae can not be used for this family; I use the next most familiar, and I think, next oldest name.

*Ctenucha virginica.* June to July. Bog B; Shack; B. Cr.

*Scepsis fulvicollis.* July to August. Bog 1; Shack; B. Cr.

## *Suborder Rhopalocera*

### *Family Hesperiidae (Skippers)*

*Pamphila* (Poanes) *hobomok.* June. Bog B; S. Br.

*P.* (Euphyes) *vestris.* B. Cr., July.

*P.* (Polites) *cernes.* June. A. Br.; B. Cr.

*P.* (Polites) *peckius.* B. Cr., September 1.

*P.* (Pamphila) *sassacus.* June to July. Bog 3; B. Cr.

**Amblyscirtes samoset.* May 29, 1915.

**Carterocephalus palaemon mandan.* May to June. Hook; A. Br.; S. Br. This, the Arctic Skipper, is not rare along the edges of the bogs. It must be very near its southern limit.

*Thanaos juvenalis.* Bog A, June 18.

*Epargyreus tityrus.* Shack, July 1.

### *Family Papilionidae (Swallowtails)*

*Papilio* (Euphoeades) *troilus.* Mud P., July 7.

*P.* (Jasoniades) *glaucus,* normal form *turnus.* Mud P., May to June.

### *Family Pieridae*

*Eurymus philodice* (Sulphur B.). Abundant everywhere.

*Pieris rapae* (Cabbage B.). Abundant everywhere, except in the woods.

**P. virginiensis* (Southern Mustard White). May to June 17. Shack; Hook, and general on the ridges about the bogs in the woods. This species seems to have been completely driven to cover by *P. rapae;* at least it is rarely seen in the sunny spots that *rapae* rarely leaves. The fact that it is single brooded indicates it is a distinct species from *P. oleracea,* which has two broods over its entire New York range.

### *Family Lycaenidae*

*Plebeius* (Lycaenopsis) *argiolus pseudargiolus.* Bog A, June 16; Mud P., July 28. The earliest spring form, lucia, seems to be absent in the entire Ithaca district, the form series beginning with marginata.

*P.* (Everes) *comyntas.* August. Mud P.; I. Br.

**Heodes epixanthe.* July to August. Bog A; Bog B; Hook (a stray specimen).

*H. thoe.* B. Cr., July 16. This is an extremely local swamp species, but is known from several other stations about Ithaca.

*H. phlaeas hypophlaeas.* May to August. Bog C; B. Cr.

**Feniseca tarquinius.* A. Br., June 20.

**Thecla* (*Incisalia*) *augustus.* May. Apparently a bog species under local conditions.

*T.* (*I.*) *niphon.* May 31, 1913.

*T.* (*Strymon*) *titus.* Bog 2, July to August.

*Family Nymphalidae*

*Basilarchia disippus.* August. Bog 3; B. Cr.

*B. arthemis.* July. Mud P.; S. Br. Nakahara seems to see a transition to *B. albofasciata* in these specimens, but they seem to me fairly normal *B. arthemis.* The dark form, *proserpina,* certainly is normal in character.

*B. a.,* form *proserpina.* Mud P., June.

*Vanessa atalanta.* July to August. Bog A; Mud P.

*Aglais antiopa.* July. Bog A; Shack.

*Polygonia comma.* July 20 to 23. S. Br.; A. Br.

*P. interrogationis* (typical). B. Cr., September.

*Form umbrosa.* July.

*Phyciodes tharos.* Generally abundant.

**Melitaea* (*Cinclidia*) *harrisii.* June 26 to July 2. Bog A; Bog 2; Mud P. An acid swamp species.

*M.* (*Euphydryas*) *phaëton.* Abundant in May. A swamp species but not confined to the bogs nearly as strictly as *M. harrisii.*

*Brenthis bellona.* May 29, 1915.

*B. myrina.* General, June 22 to August 8.

*Argynnis atlantis.* B. Cr., September 1, 1925.

*A. aphrodite.* B. Cr., July to August.

*A. cybele.* July to August. SE. Sl.; B. Cr. (common).

*Cercyonis nephele.* August. I. Br.; B. Cr.

**Satyrodes canthus.* July. W. R.; Bog A; Bog 1; S. Br. Common in swamps.

**Enodia portlandia.* July. A. Br.; S. Br.; W. R.; I. Br. Quite a rarity.

*Cissia eurytus.* June. W. R.; H. R.; S. Br. An abundant upland species.

## COLEOPTERA

List Prepared by F. C. Fletcher

The following list of six hundred and fourteen species of Coleoptera from McLean is based upon material collected by the following:

| | | |
|---|---|---|
| Babiy, P. P. and Edith | Crosby, C. R. | Leonard, M. D. |
| Barnes, T. C. | Dietrich, H. | Liu, C. L. |
| Bissel, Theo. | Fletcher, F. C. | Sandhouse, G |
| Bradley, J. C. | Forbes, W. T. M. | Seeley, R. |
| Chapman, P. J. | Good, Henry | Sibley, C. K. |
| Claassen, P. W. | Gordon, M. | West, L. S. |

These members of Ithaca scout troop No. 15 also have contributed material for this list: Armand Adams, Temple Scofield, K. E. Caster, John Matteson and Watson Shevalier.

The numbers which precede the names of species correspond to Leng's list.[1]

### *Family Cicindelidae*

50. *Cicindela repanda.* July.
69. *C. sexguttata.* May 19 to 28.

### *Family Carabidae*

128. *Scaphinotus viduus.* H. R., September; Shack, September; Mud P., August.
162. *Sphaeroderus lecontei.* April 17 to May 16; H. R., September.
183. *Calosoma frigidum.* June.
204. *C. calidum.* June 3 to July 3.
222. *Elaphrus clairvillei.* May 16.
225. *E. olivaceus.* May 30.
226. *E. cicatricosus.* May 30.
237. *Blethisa quadricollis.* July 7 to August 8.
241. *Loricera caerulescens.* April 17.
246. *Notiophilus aeneus.* April 17.
292. *Nebria pallipes.* August 12; Shack, September.
324. *Dyschirius nigripes.* August 8.

[1] Leng, C. W. A Catalog of the Coleoptera of North America, Mt. Vernon, New York, 1920.

Determinations of species have been made by F. C. Fletcher, Henry Dietrich, H. G. Good and Dr. E. C. Van Dyke; also in a few cases by Dr. L. S. West, John D. Sherman, Jr., H. C. Fall, M. H. Hatch and T. L. Bissell. The manuscript list prepared by Mr. Fletcher, showing by whom each determination was made, is on file in the Cornell University Collection.

331. *D. globulosus.* July 28.
369. *Clivina americana.* July 7 to 28.
512. *Bembidion nigrum.* August.
572. *B. picipes.* August 12.
588. *B. tetracolum.* August 12.
655. *B. intermedium.* August 8.
660. *B. variegatum.* August 8.
730. *B. oberthüri.* August 8.
737. *B. quadrimaculatum.* May 31.
754. *B. sulcatum.* April 17.
805. *Tachyura incurva.* August 8.
830. *T. vivax.* August 8.
849. *Tachys proximus.* August 8.
883. *T. laevus.* April 17, August 8.
898. *Tachymenis flavicauda.* April 17.
901. *Patrobus longicornis.* B. Br.; B. Cr.; Mud P.; W. R., April 17 to September.
935. *Cylindrocharis piceata.* B. Cr.; B. Br.; Shack;, April 17 to July 7.
1006. *Pterostichus adoxus.* May 20 to July 7.
1024. *Gastrellarius honestus.* B. Cr., September 14, April 17 to July 7.
1077. *Monoferonia osculans.* Shack; B. Cr.; H. R., April 17 to September.
1089. *Euferonia stygica.* B. Cr.; Shack, April 17 to July 7.
1093. *E. coracina.* B. Cr.; Shack, April 17 to September.
1097. *E. lachrymosa.* Shack, April 17 to August.
1162. *Poecilus lucublandus.* S. Br., April 17 to July 7.
1175. *Omaseus luctuosus.* July 7.
1176. *O. corvinus.* July 7.
1178. *Dysidius mutus.* April 17 to July 7.
1181. *Pseudargutor erythropus.* April 17 to July 7.
1182. *Micromaseus patruelis.* July 7.
1188. *Bothriopterus pennsylvanicus.* S. Br., April 17 to July 7.
1272. *Bradytus latior.* July 3.
1385. *Amara impuncticollis.* April 17 to July 7.
1400. *A. cupreolata.* April 17.
1442. *Rembus laticollis.* July 7 to 29.
1443. *R. impressicollis.* July 3 to 28.
1446. *R. alternans.* July 7.
1450. *Dicaelus dilatatus.* July 3.
1465. *D. elongatus.* July 7.
1467. *D. teter.* SE. Sl.; W. R., April 17 to September.
1468. *D. politus.* April 17.
1479. *Badister micans.* August 7.

1481. *B. reflexus.* August 8.
1482. *Calathus gregarius.* W. R., September, April 17 to July 3.
1484. *C. opaculus.* July 2, November 1, December 20.
1489. *Pristodactyla impunctata.* W. R., September.
1507. *Platynus hypolithos.* H. R.; Shack; B. Cr., April 17 to September.
1508. *P. angustatus.* H. R.; Shack; W. R.; I. Br.; B. Cr.; SE. Sl.; Obsv. Hill, June to September.
1514. *P. sinuatus.* I. Br.; A. Br., May to September.
1519. *P. reflexus.* June 3.
1522. *P. extensicollis.* July 3 to August 12.
1523. *P. decorus.* July 7.
1541. *P. mutatus.* April 17 to July 7.
1542. *P. melanarius.* July 7 to August 7.
1546. *P. affinis.* August 7.
1553. *P. cupripennis.* April 17 to July 7.
1566. *P. octopunctatus.* July 28.
1567. *P. placidus.* Shack, April 17 to August.
1577. *P. aeruginosus.* Mud P., July.
1584. *P. ruficornis.* August 3.
1588. *P. lutulentus.* Shack, April 17 to July.
1616. *Galerita janus.* April 17 to August 3.
1641. *Lebia grandis.* S. Br., June.
1642. *L. atriventris.* Shack, June.
1655. *L. viridis.* B. Cr., September.
1667. *L. ornata.* S. Br., July.
1746. *Cymindis pilosa.* B. Cr., April 17 to September.
1752. *C. americana.* July 7 to 10.
1779. *Brachinus medius.* July 19 to August 8.
1783. *B. cyanipennis.* July 3 to 28.
1788. *B. ballistarius.* November 6.
1789. *B. fumans.* April 17 to July 7.
1790. *B. cordicollis.* April 17 to August 7.
1817. *Chlaenius pennsylvanicus.* Bog 2; Mud P.; Shack, July, August.
1821. *C. tricolor.* W. R.; B. Cr.; Shack, April 17 to September.
1822. *C. nemoralis.* August 8.
1846. *C. sericeus.* H. R., September, April 17 to July 7.
1856. *Anomoglossus emarginatus.* H. R., April 17, September.
1867. *Oodes amaroides.* July 7 to 28.
1903. *Harpalus viridiaeneus.* May 31.
1907. *H. vagans.* H. R.; Shack, July to September.
1910. *H. erythropus.* Shack, April 17 to August.
1915. *H. compar.* July 3 to August 7.

1956. *H. herbivagus.* April 17 to July 7.
2009. *H. vulpeculus.* Shack; SE. Sl.; B. Cr., May 16 to September.
2013. *Selenophorus opalinus.* July 7.
2087. *Anisodactylus harrisi.* April 17 to July 28.
2088. *A. nigerrimus.* April 17.
2091. *A. interpunctatus.* July 7 to 28.
2110. *Xestonotus lugubris.* April 17 to November 1.
2126. *Anadaptus discoideus.* Shack, June to July.
2127. *A. baltimorensis.* W. R., July 7 to September.
2139. *Anisotarsus terminatus.* Shack, August to September.
2171. *Stenocellus rupestris.* Shack; I. Br., April 17 to August 8.
2195. *S. tantillus.* April 17 to July 28.
2213. *Acupalpus carus.* July 28 to August 8.
2218. *Stenolophus ochropezus.* August 8.
2220. *S. fuliginosus.* July 7 to 25.
2234. *S. plebejus.* July 8.
2256. *Agonoderus pallipes.* Shack; Mud P., June to July.

### *Family Omophronidae*

2284. *Omophron americanum.*

### *Family Haliplidae*

2305. *H. cribrarius.* August 7.
2318. *H. ruficollis.* June 6 to September 17; Mud P., July.
2337. *Peltodytes edentulus.* Mud P., August.

### *Family Dytiscidae*

2351. *Laccophilus maculosus.* Mud P., July, August.
2390. *Bidessus affinis.* Mud P., July, August 7.
2403. *Coelambus inaequalis.* Mud P., July, May 21 to July 7.
2409. *C. dispar.* August.
2429. *Hydroporus catascopium.* July 7 to October 21.
*H. filiolus.* August 7.
2447. *H. undulatus.* October 21.
2452. *H. clypealis.* August 7.
2463. *H. mixtus.* May 21.
2498. *H. appalachius.* August 7.
2501. *H. tristis.* July in bottle trap.
2514. *H. niger.* June to July; July in bottle trap.
2521. *H. stagnalis.* July in bottle trap.
2551. *Agabus punctulatus.* July 27.

2557. *A. disintegratus.* August 7.
2562. *A. reticulatus.* August; July, Bog B in bottle trap.
2580. *A. gagates.* August; July in bottle trap.
2598. *Ilybius biguttulus.* July 27 to August 7; July in bottle trap.
2605. *Copelatus glyphicus.* July in bottle trap.
2610. *Coptotomus interrogatus.* August 7.
2616. *Rhantus binotatus.* Bog B in bottle trap, July.
2632. *Colymbetes sculptilis.* Mud P.; B. Cr., July.
2637. *Dytiscus hybridus.* Mud P., July.
2646. *D. harrisi.* October 21.
2651. *Acilius semisulcatus.* Mud P.; B. Cr., June to August. In meat trap.
2655. *Thermonectes basilaris.* July 3.
2659. *Graphoderes liberus.* July 6 to August 7.
2660. *G. cinereus.* August 7.

*Family Gyrinidae*

2680. *Dineutes americanus.* May to July.
*Gyrinus lecontei.* October.
2696. *G. affinis.* October.
2700. *G. analis.* May.
*G. lugens.* May.

*Family Hydrophilidae*

2718. *Ochthebius tuberculatus.* July 8.
2729. *Hydraena pennsylvanica.* July 8.
2743. *Helophorus lacustris.*
2750. *H. lineatus.* B. Cr.; Mud P., July.
2764. *Hydrochus squamifer.* August.
2777. *Berosus peregrinus.* Mud P.
2784. *B. striatus.* July 7.
2789. *Hydrous triangularis.* July 8.
2795. *Hydrophilus obtusatus.* July.
2805. *Tropisternus glaber.* Mud P., July.
2806. *T. mixtus.* May 16 to October 21; Mud P., August.
2807. *T. lateralis.* July 3.
2808. *Hydrobius fuscipes.* Shack; Mud P., July.
2810. *H. globosus.* July 3 to August 7; I. Br., September.
2814. *Anacaena infuscata.* August 7; July in bottle trap.
2819. *Paracymus subcupreus.* May 16 to August 7; July in bottle trap.
2835. *Enochrus ochraceus.* S. Br., June; Mud P., July; Shack, August.
2836. *E. perplexus.* August 7; Mud P., July; July in bottle trap.
2837. *E. cinctus.* August 7; Shack, June; Mud P., July.

2838. *E. consors.* No data.
2841. *E. hamiltoni.* Bog A, August; Mud P., July.
2851. *Cimbiodyta blanchardi.* Bog 1, July.
2852. *C. lacustris.* Bog 1, June 21 to July.
2853. *Helocombus bifidus.* July.
2854. *Laccobius agilis.* July 8.
2867. *Sphaeridium scarabaeoides.* July 3.
2873. *Cercyon unipunctatus.* August.
2876. *C. praetextatus.* Mud P., September.
2899. *Cryptopleurum minutum.* August.

*Family Silphidae*

2912. *Necrophorus sayi.* July 3.
2913. *N. orbicollis.* May; Shack, June; Hook, July.
2918. *N. pustulatus.* July 8.
2919. *N. vespilloides.* Hook, June; Bog A, August.
2920. *N. tomentosus.* Bog A; B. Cr., August.
2922. *Silpha surinamensis.* April 17, July 3.
2927. *S. noveboracensis.* Bog A; Bog B, August; Shack, September.
2928. *S. americana.* May 27, July 3; Bog A, August.
2950. *Choleva simplex.* Shack.
2957. *Prionochaeta opaca.* May 16; Shack, June.
3000. *Anisotoma assimilis.* June 21.
3027. *Leiodes geminata.* Shack, June.

*Family Scydmaenidae*

3150. *Connophron capillosulum.* May 16.
3168. *Scydmaenus perforatus.* May 16.

*Family Staphylinidae*

3315. *Thoracophorus costalis.* May 16.
3339. *Anthobium convexum.* I. Br., May 16; Mud P., June 24.
3420. *Arpedium schwarzi.* May 16.
3462. *Geodromicus strictus.* August 12.
3719. *Stenus juno.* May 16.
3736. *S. erythropus.* May 16.
3782. *S. humilis.* May 16.
3832. *S. flavicornis.* Hook, May 22; I. Br., May 16; Shack, June 9; W. R., August 22.
3833. *S. annularis.* May 16.
3926. *Hesperobium pallipes.* April 17.

3933. *H. cribratum.* April 17 to May 16.
3952. *Paederus littorarius.* April 17 to June 21.
3966. *Lathrobium armatum.* July 7 to 28.
3969. *L. migrolucens.* May 16.
3983. *L. neglectum.* May 16.
4012. *Lathrobioma scolopacea.* June 21.
4031. *Eulathrobium grande.* July 28.
4248. *Stilicus dentatus.* May 16.
4270. *Astenus brevipennis.* May 16.
4272. *A. discopunctatus.* April 17, July 28.
4285. *Nudobius cephalus.* B. Cr., September 20.
4308. *Gyrohypnus hamatus.* April 17.
4361. *Neobisnius sobrinus.* August 8.
4364. *N. paederoides.* July 28.
4384. *Philonthus politus.* April 17.
4414. *P. palliatus.* May 30.
4418. *P. quadricollis.* May 30 to July 28.
4441. *P. micans.* August 8.
4443. *P. lomatus.* May 16.
4446. *P. brunneus.* April 17.
4447. *P. cyanipennis.* July 27.
4448. *P. blandus.* May 16.
4497. *P. aurulentus.* May 31, August 8.
4526. *Staphylinus badipes.* April 17.
4533. *S. maculosus.* H. R., June 23.
4534. *S. mysticus.* April 17.
4545. *S. cinnamopterus.* July 28.
4546. *S. violaceus.* July 7; Shack, September 13.
4552. *Ontholestes cingulatus.* Bog A, August 4 to 26; A. Br., September 19.
4555. *Creophilus maxillosus* var. *villosus.* July 27.
4565. *Acylophorus pronus.* May 30 to August 8.
4578. *Quedius vernix.* July 28, August 26.
4579. *Q. molochinus.* June 21.
4586. *Q. capucinus.* B. Cr., September 14.
4595. *Q. peregrinus.* July 16.
4637. *Oxyporus lateralis.* May.
4657. *Tachinus repandus.* May 16, July 7.
4663. *T. flavipennis.* W. R., June 25; H. R., June 23; Shack, June 9; I. Br., May 16.
4664. *T. luridus.* Shack, June 9.
4665. *T. fimbriatus.* Bog 3, September 12.
4674. *T. nitiduloides.* July 16.

4678. *Tachyporus maculipennis.* May 16.
4682. *T. chrysomelinus.* I. Br., May 22.
4690. *Erchomus ventriculus.* B. Cr., September 20, May 16.
4695. *Conosoma knoxi.* Hook, May 22.
4707. *C. crassus.* April 17.
4723. *Bolitobius cincticollis.* May 16.
4737. *Bryoporus rufescens.* May 16.
4743a. *Mycetoporus flavicollis* var. *pictus.* May 16.
4760. *Gymnusa brevicollis.* May 16.
5743. *Meronera venustula.* August 8.
5751. *Alcodorus bilobatus.* May 16.
5774. *Aleochara pleuralis.* July 28.

*Family Pselaphidae*

6158. *Rhexius insculptus.* May 16.
6200. *Batrisodes globosus.* April 17.
6263. *Reichenbachia cribricollis.* May 16.
6310. *Rybaxis conjuncta.* Mud P., June 22; B. Cr., September 20, May 6.
6351. *Pselaphus erichsoni.* May 16.

*Family Ptiliidae*

6417. *Ptenidium pusillum.* May 16.
6459. *Acratrichis haldemani.* May 16.

*Family Scaphidiidae*

6513. *Baeocera apicalis.* May 16.

*Family Histeridae*

6571. *Hister interruptus.* Shack, June 27; B. Cr., July 16.
6573. *H. immunis.* May 16; Mud P., June 24.
6586. *H. foedatus.* Shack, June 27.
6596. *H. abbreviatus.* May.
6627. *H. americanus.* June 21.
6653. *Platysoma depressum.* May 16.
6827. *Saprinus lugens.* April 22.
6836. *S. assimilis.* April 22.

*Family Lycidae*

6926. *Calopteron reticulatum.* July 3.
6939. *Eros aurora.* May, June 2.
6945. *Plateros modestus.* Bog A, July.
6950. *P. floralis.* Bog A, July.

*Family Lampyridae*

6971. *Lucidota atra.* H. R., June 23.
6975. *L. corrusca.* Bog 1, September 20; A. Br., September 20; Mud P., September 20; Shack, June 12; SE. Sl., September 16; Bog B, May 28; S. Br., September 14; I. Br., June 28.
6988. *Photinus consanguineus.* July 3; Shack, June 23 to July 22.
6990. *P. ardens.* July 3.
6996. *P. pyralis.* June 24.
7013. *Photuris pennsylvanica.* Shack, July 23.

*Family Cantharidae*

7051. *Chauliognathus pennsylvanicus.* Bog 2, August 23; Bog 3, August 22; Bog 1, August 27; B. Cr., August 19.
7055. *Podabrus tricostatus.* June 24; Mud P., June 24; Hook, June 18; W. R., June 20; Shack, June 23; S. Br., July 1; Bog A, June 28; I. Br., June 4.
7058. *P. basillaris.* June 24.
7062. *P. modestus.* July 7.
7091. *Cantharis dentiger.* May 29.
7096. *C. fraxini.* July.
7097. *C. carolinus.* May 30.
7100. *C. nigritulus.* June 24.
7101. *C. rectus.* June 24.
7113. *C. rotundicollis.* Bog 2, June 30; Shack, June 30.
7119. *C. tuberculatus.* S. Br., June 19; Hook, June 16; Bog 2, July 2; Mud P., June 24.
7121. *C. bilineatus.* I. Br., May 16; Bog C, May 23.
7157. *Silis spathulata.* May 29.

*Family Melyridae*

7238. *Malachius aeneus.* July 3; Shack, June 22; I. Br., May 22.
7294. *Attalus terminalis.* May 16.

*Family Cleridae*

7629. *Trichodes nutalli.* July 19.

*Family Corynetidae*

7729. *Necrobia violacea.* May, August 8.

*Family Oedemeridae*

7800. *Asclera ruficollis.* May 8 to 29.

*Family Mordellidae*

7804. *Tomoxia bidentata.* Bog A, July 16.
7810. *Mordella melaena.* July 8.
7811. *M. atrata.* July 28.
7814. *M. octopunctata.* July 3.
7817. *M. marginata.* July; Bog A, June 19.
7834. *Mordellistena confusa.* June 30.
7860. *M. aspersa.* August 3.
7862. *M. tosta.* Bog A, July 26.
7893. *M. morula.* I. Br., June 19.
7901. *M. marginalis.* Shack, June 27.

*Family Meloidae*

7990. *Pomphopoea sayi.* June 22; Bog A, June 25; Hook, June 27.
8033. *Epicauta pennsylvanica.* July 3 to 18.
8042. *Macrobasis unicolor.* Bog A, June 25.
8147. *Meloe angusticollis.* S. Br., September 16, April 17.

*Family Pythidae*

8204. *Pytho planus.* July 3.
8217. *Rhinosimus viridiaeneus.* April 17.

*Family Pyrochroidae*

8226. *Dendroides concolor.* H. R., June 27; Shack, June 23; S. Br., June 20.

*Family Pedilidae*

8243. *Pedilus canaliculatus.* May 3 to 21.
8244. *P. elegans.* May 29.
8245. *P. terminalis.* May 16.
8248. *P. newmani.* August 3.

*Family Anthicidae*

8302. *Notoxus anchora.* Shack, July 24 to August 24; Bog 1, July 7.
8387. *Anthicus floralis.* Bog 1, August 20.

*Family Euglenidae*

8501. *Tanilotes densus.* Bog B, August 30.

*Family Elateridae*

8571. *Alaus oculatus.* May 30.
8607. *Monocrepidius auritus.* April 17, May 30.

8667. *Athous cucullatus.* July to August.
8699. *Lepturoides denticornis.* June.
8721. *Ludius cylindriformis.* May 16.
8748. *L. sulcicollis.* June 22.
8796. *L. hieroglyphicus.* May 30 to July 3.
8813. *Hemicrepidius decoloratus.* July 3.
8814. *H. memnonius.* July 7.
8878. *Dalopius lateralis.* May, July; A. Br., July 20; Mud P., June 24; Shack, June 19; S. Br., June 10; Bog 2, June; Hook, July.
8885. *Agriotes mancus.* April 17.
8888. *A. fucosus.* May 30; Shack, June, April 17.
8934. *Elater nigricollis.* May 30.
8935. *E. linteus.* July 3, May 16.
8940. *E. verticinus.* July 3.
8941. *E. semicinctus.*
8943. *E. rubricus.* May 30, July 3; Bog B, June 19; Mud P., June 24.
8960. *E. pedalis.* May 30, July 3; Bog A, June 28.
8964. *E. mixtus* var. *fusculus.* May 30; Hook, June 16; Bog 2, July 2; Bog A, June 25; Bog B, June 19; Mud P., June 24.
8968. *E. luctuosus.* May 30.
8969. *E. nigricans.* May 30 to July 3.
9015. *Melanotus castanipes.* May.

*Family Melasidae*

9133. *Deltometopus amoenicornis.* August.

*Family Throscidae*

9204. *Throscus chevrolati.* Shack, June 21.

*Family Buprestidae*

9333. *Dicerca divaricata.*
9342. *D. lurida.* May 31.
9513. *Agrilus ruficollis.* Bog B, August 30.
9572. *Brachys aerosus.* May 30; B. Cr., June 16; Mud P., June 24; I. Br., June 4.

*Family Psephenidae*

9586. *Psephenus lecontei.* S. Br., July 25; Mud P., July 12.

*Family Dryopidae*

9603. *Helichus lithophilus.* May.
9604. *H. fastigiatus.* May 16.

*Family Helmidae*

9618. *Helmis quadrinotata.* May.
9634. *Limnius fastiditus.* Mud P., July 12.
9640. *Machronychus glabratus.* May to July.

*Family Heteroceridae*

9646. *Heterocerus undatus.* July 17.
9651. *H. tristis.* B. Cr., July 16; Mud P., July 7, May 16.

*Family Helodidae*

9692. *Cyphon ruficollis.* I. Br., June 4.
9696. *C. obscurus.* I. Br., May 22; A. Br., July 20.
9698. *C. variabilis.* Bog 1, August; Mud P., June to July; Shack, July; A. Br., July; S. Br., June.
9699. *C. padi.* August 27.
9704. *Prionocyphon limbatus.* A. Br., August 28; Shack, July 10.
9708. *Scirtes tibialis.* Mud P., August 12; Shack, July 24.
9716. *Ptilodactyla serricollis.* August 27.

*Family Dermestidae*

9718. *Byturus unicolor.* S. Br., July 12.
9737. *Dermestes lardarius.* May 21.
9835. *Anthrenus verbasci.* Hook, August 24; Bog 1, July 7.

*Family Byrrhidae*

9864. *Cytilus alternatus.* May 16, July 3.
9869. *Byrrhus americanus.* July 28.
9895. *Syncalypta spinosa.* May 16.
9905. *Limnichites punctatus.* Hook, May 22.

*Family Rhysodidae*

9944. *Rhysodes americanus.* November 1.

*Family Ostomidae*

9994. *Tenebroides corticolis.* H. R., June 23.

*Family Nitidulidae*

*Brachypterolus pulicarius.* May 22.
10035. *Conotelus obscurus.* June 6.
10069. *Omosita colon.* August 8.
10077. *Epuraea erichsoni.* July.

10109. *Phenolia grossa.* May 29.
10137. *Glischrochilus fasciatus.* July 3; Mud P., June.

*Family Cucujidae*

10211. *Catogenus rufus.* August.
10273. *Brontes clubius.* May 13 to June 3.

*Family Erotylidae*

10282. *Languria mozardi.* Bog 1, June.
10292. *Acropteroxys gracilis.* Bog 2, July.
10347. *Triplex thoracica.* Shack, June.
10347. *Megalodacne fasciata.* July 3.

*Family Cryptophagidae*

10463. *Anchicera ephippiata.* Mud P., June 24; Bog 1, August 20.

*Family Mycetophogidae*

10490. *Mycetophagus punctatus.* July 19.
10491. *M. flexuosus.* May 16.

*Family Colydiidae*

10598. *Cerylon castaneum.* May 16.

*Family Lathridiidae*

10631. *Lathridius liratus.* Mud P., June; Shack, June 19.
10701. *Melanophthalma distinguenda.* May 30; Mud P., June 24; Bog 1, August 20; Shack, July 29.

*Family Endomychidae*

10720. *Lycoperdina ferruginea.* May 16.
10726. *Aphorista vittata.* April 17.
10727. *Mycetina perpulchra.* H. R., June 23.
10753. *Endomychus biguttatus.* Hook, July 16.

*Family Phalacridae*

10780. *Olibrus semistriatus.* I. Br., May 22; Mud P., June 24.
10829. *Stilbus apicalis.* May 16.

*Family Coccinellidae*

10879. *Hysperaspis signata.* July.
10923. *H. lugubris.* Hook, May 22.

10930. *H. undulata.* July 18.
10972. *Brachyacantha ursina.* I. Br., June 19.
11094. *Scymnus ornatus.* Bog 1, July 17.
11147. *Coccidula lepida.* May 31.
11150. *Psyllobora viginti-maculata.* May 16.
11154. *Anisosticta bitriangularis.* August 8; Mud P., June; Bog 1, August.
11158. *Ceratomegilla fuscilabris.* July 3, April 17; Mud P., June; Bog 3, September.
11162. *Hippodamia tredecim-punctata.* H. R., July.
11163. *H. parenthesis.* July 28; I. Br., June 4.
11171. *H. glacialis.* July 3.
11181. *Coccinella perplexa.* May 31, July 3.
11184. *C. novemnotata.* May 30 to July.
11185. *C. transversogutta* var. *quinquenotata.* June, July.
11189. *Cycloneda sanguinea.* May 16.
11193. *Adalia bipunctata.* Shack; Mud P., July.
11202. *Anatis quindecimpunctata.* S. Br., June.
11217. *Chilocorus bivulnerus.* May 30.

*Family Alleculidae*

11246. *Hymenorus niger.* Shack, August 28.
11307. *Isomira sericea.* May 20.
11320. *Capnochroa fuliginosa.* Shack, August 31.
11324. *Mycetochara megalops.* Shack, July 7.
11355. *Androchirus erythropus.* Shack, July 18.

*Family Tenebrionidae*

11671. *Phellopsis obcordata.* July 3.
12207. *Blapstinus metallicus.* April 17.
12208. *B. interruptus.* July 7.
12295. *Bolitotherus cornutus.* July 3.
12296. *Bolitophagus corticola.* May 30.
12305. *Diaperis maculata.* May 30.
12309. *Hoplocephala bicornis.* July 8.
12323. *Platydema americanum.* May 16.
12353. *Uloma impressa.* May 29.
12357. *U. punctulata.* July 3.
12386. *Scotobates calcaratus.* B. Cr., July 10; Bog B, June 19.
12390. *Xylopinus saperdioides.* May 22.
12407. *Alobates pennsylvanica.* July 3.
12414. *Tenebrio molitor.* Shack, July 22, August 30.
12425. *Anaedus brunneus.* June.

*Family Lagriidae*

12497. *Arthromacra aenea.* July 3; B. Cr., July 18; Shack, June 27; Bog B, June 19; I. Br., June 4.

*Family Melandryidae*

12527. *Penthe obliquata.* July 22.
12529. *Synchroa punctata.* June 6.
12531. *Eustrophinus bicolor.* August 2.
12546. *Orchesia castanea.* Bog 3, August 22.
12552. *Melandrya striata.* July 3 to 7; H. R., June.
12585. *Canifa plagiata.* July 4.

*Family Anobiidae*

12639. *Eucrada humeralis.* May 31.
12709. *Hadrobregmus umbrosus.* May 16.

*Family Bostrichidae*

12871. *Endecatomus rugosus.* May 7.

*Family Cisidae*

12997. *Xestocis levetti.* May to June.

*Family Scarabaeidae*

13080. *Onthophagus hecate.* July 7, April 17.
13107. *Aphodius fossor.* July 3.
13110. *A. erraticus.* April 17.
13119. *A. fimetarius.* July 3; B. Cr., September 14.
13127. *A. ruricola.* August 8; Shack, August 28.
13131. *A. granarius.* June 6.
13184. *A. distinctus.* June 6.
13233. *Ataenius cognatus.* Shack, June.
13286. *Odontaeus filicornis.* Shack, August.
13290. *Geotrupes balyi.* Shack, September.
13354. *Serica vespertina.* Mud P., June 10; Shack, June 24.
13364. *S. serica.* May 30.
13511. *Phyllophaga fusca.* June 8.
13516. *P. anxia.* June 2.
13538. *P. hirticula.* Shack, June 23.
13563. *P. tristis.* June 8.
13649. *Dichelonyx elongata.* May 30; Bog A, June 12; Shack, June 10; S. Br., June 13; Hook, June 16; W. R., June 16.

13747. *Strigoderma arboricola.* June.
13755. *Pelidnota punctata.* Bog B, September 7.
13940. *Euphoria inda.* May to June.
14010. *Osmoderma scabra.* July to August.
14012. *O. eremicola.* June 7.
14016. *Trichiotinus piger.* July 17.

*Family Trogidae*

13338. *Trox unistriatus.* B. Cr., July 16.
13344. *T. scaber.* B. Cr., July 16.

*Family Lucanidae*

14034. *Pseudolucanus capreolus.* June 6.
14039. *Dorcus parallelus.* B. Cr., August 30.
14041. *Platycerus quercus.* July 7; S. Br., June 28.

*Family Passalidae*

14064. *Passalus cornutus.* November 1.

*Family Cerambycidae*

14067. *Parandra brunnea.* B. Cr., September 14.
14081. *Derobrachus brunneus.* Shack, August 13.
14211. *Hypermallus villosus.* June 5.
14298. *Rhagium lineatum.* September 18.
14308. *Hapalosalia vibex.* H. R., May 23; Bog 3, June 19.
14323. *Stenocorus trivittatus.* June 5.
14349. *Evodinus monticola.* May 29 to 31.
14415. *Anthophilox attenuatus.* May 29.
14426. *Judolia cordifera.* May 16.
14438. *Brachyleptura rubrica.* July 27 to 29.
14459. *Parallelina subargentata.* Mud P., June 24.
14465. *Strangalepta lineola.* July 7.
14466. *S. pubera.* July.
14469. *S. vittata.* July 31.
14530. *Leptura biforis.* July.
14630. *Phymatodes amoenus.* September 3.
14728. *Anthoboscus ruricola.* May 31, July.
14901. *Monochamus notatus.* Shack, September 13.
15112. *Saperda candida.* Bog 3, September 7.

15117. *S. vestita.* May.
15138. *Oberea tripunctata.* July 7; S. Br., July 12.
15148. *O. bimaculata.*

*Family Chrysomelidae*

15208. *Donacia harrisi.* July.
15214. *D. germari* (serricauda Sch.). May.
15215. *D. metallica.* May.
15216. *D. biimpressa* (*D. torosa* Lec. *D. distinctus* Lg. not Lec). May.
15217. *D. flavipes.* May 3; Mud P., June 19.
15219b. *Orsodacne atra* var. *hepatica.* April 17.
15219e. *O. atra* var. *trivittata.* Mud P., June 24.
15223. *Syneta ferruginea.* I. Br., May 16.
15262. *Antipus laticlavia.* June 7.
15297. *Chlamys gibbosa.* Bog A, August 26.
15459. *Pachybrachys trinotatus.* I. Br., June.
15480. *Cryptocephalus quadruplex.* May 30.
15507. *C. mutabilis.* July 3.
15521. *Diachus auratus.* Bog 3, August 22; Bog A, August 11; Bog C, August 20.
15528. *D. pallidicornis.* June 30.
15534d. *Bassareus mammifer* var. *sellatus.* S. Br., September.
15549. *Nodonota puncticollis.* S. Br., July 12; Bog 3, August 22.
15555. *Colaspis brunnea* var. *flavida.* July.
15563. *Rhabdopterus picipes.* Shack, August 31, September 13.
15567. *Grahops pubescens.* Hook, May 16.
15573. *Xanthonia decemnotata.* I. Br., May 22.
15626a. *Paria canella* var. *aterrima.* I. Br., May 16.
15636. *Prasocuris vittata.* May 30; A. Br., June 18; I. Br., May.
15639. *Labidomera clivicollis.* July 3; B. Cr., July 10.
15648. *Leptinotarsa decemlineata.* Bog 2, August 23.
15669. *Calligrapha elegans.* July 28.
15672. *C. rhoda.* May 29.
15674. *C. philadelphica.* May 30.
15677. *C. bigsbyana.* Bog 2, June 16; Bog 3, August 22; A. Br., June 5; I. Br., September 23; Bog A, June 25, May 16.
15693. *Plagiodera versicolora.* I. Br., May 16, June 21.
15701. *Gastroidea polygoni.* I. Br., May 22.
15708. *Lina lapponica.* May 30; I. Br., May.
15726. *Trirhabda virgata.*
15745. *Galerucella sexvittata.* Bog 1, July 17.
15746. *G. clavicollis.* May.
15747. *G. rufosanguinea.* May 29.

15752. *G. tuberculata.* Bog 1, September 6; Mud P., June 24; Bog B, August 28; Bog 3, September 7; B. Cr., July 16; Bog 2, July 2; S. Br., June 10.
15753. *G. decora.* May 30.
15769. *Diabrotica duodecimpunctata.* August 8.
15782. *D. vittata.* Bog 3, September 19; SE. Sl., September 11.
15823. *Luperodes meraca.* S. Br., June 23; Shack, June 5; B. Cr., June 10; H. R., June 23.
15868. *Oedionychis vians.* July 7.
15886. *O. limbalis.* May 30; Bog 2, July 2; Shack, July 5; Mud P., June 20.
15886a. *O. limbalis* var. *subvittata.* I. Br., May 22.
15895. *Disonycha pennsylvanica.* May 8.
15917. *Haltica chalybea.* July 28.
15920. *H. ignita.* May 30.
15949. *H. fuscoaenea.* August 8.
15968. *Chalcoides helxines.* May 30; SE. Sl., August 20; Bog B, September 16; Bog 2, June 16; Hook, September 3; B. Br., September 21; Mud P., June 24; A. Br., September 23.
15974. *C. atriventris.* May 22.
15982. *Epitrix cucumeris.* May 30; SE. Sl., August 20; I. Br., June 30; Bog 1, September 17; A. Br., August 28; Bog 3, August 22; W. R., August 22; Shack, June 9.
15988. *Orthaltica copalina.* May 16.
15993. *Mantura floridana.* May 29.
15995. *Chaetocnema cribrata.* June 19.
15998. *C. subcylindrica.* May 29, June 4.
16006. *C. minuta.* July 28, May 29.
16022. *Systena hudsonias.* June 19.
16023½. *S. frontalis.* August 31.
16049. *Longitarsus melanurus.* May 30.
16061. *Glyptina spuria.* May 30.
16066. *Phyllotreta vittata.* I. Br., June 5.
16074. *P. bipustulata.* May 16.
16075. *P. armoraciae.* I. Br., June 5.
16086. *Dibolia borealis.* May 29.
16089. *Psylliodes punctulata.* I. Br., June 5.
16105. *Anoplitis inaequalis.* Mud P., September 20.
16113. *Chalepus dorsalis.* August.
16133. *Microrhopala excavata.* Bog 3, September 7; I. Br., June.
16139. *Chelymorpha cassidea.* Bog B, June 18; SE. Sl., September 16.

*Family Platystomidae*

16299. *Euparius marmoreus.* B. Cr., September 20.
16304. *Brachytarsus sticticus.* Bog 1, September 17.

*Family Curculionidae*

16499. *Phyxelis rigidus.* July 16.
16678. *Brachyrhinus ovatus.* I. Br., September 19; Shack, August 28.
16679. *B. rugifrons.*
16727. *Sitona flavescens.* Bog 2, August 3.
16728. *S. hispidulus.* Bog 3, September 19; Bog 1, September 14; Shack, September 1.
16754. *Hypera punctata.* Bog 2, August 23; A. Br., September 12.
16765. *Phytonomus nigrirostris.* May 30.
17151. *Magdalis armicollis.* I. Br., June 4.
17186. *Tachypterellus quadrigibbus.* May 30; I. Br., June 10.
17212. *Anthonomus haematopus.* I. Br., May 22.
17217. *A. corvulus.* May 30.
17337. *Orchestes ephippiatus.* June 22.
17339. *O. niger.* May 30.
17345. *O. pallicornis.* Hook, May 22.
17353. *Piazorhinus scutellaris.* Hook, August 24; Bog 3, August 22.
17359. *Gymnetron tetrum.* June 22.
17405. *Lixus rubellus.* August 8; Shack, August 22; Bog 1, August 20.
17418. *L. concavus.* May 18 to June 16.
17468. *Baris interstitialis.* Obsv. Hill, June 28; Shack, June 21; I. Br., May 16.
17542. *Madarellus undulatus.* June 22.
17699. *Gelus oculatus.* May 30.
17726. *Acoptus suturalis.* May 31, May 16.
17728. *Mononychus vulpeculus.* May 16.
17764. *Ceutorhynchus rapae.* I. Br., June 4.
17767. *C. marginatus.* May 31; I. Br., May 16.
17783. *C. cyanipennis.* I. Br., June 4; Hook, May 22.
17828. *Pelenomus sulcicollis.* July.
17851. *Conotrachelus nenuphar.* Bog 1, May 22.
17974. *Cryptorhynchus lapathi.* May 16.
18073. *Stenoscelis brevis.* May 16.
18107. *Sphenophorus striatipennis.*
18132. *S. zeae.* July 7.

*Family Scolytidae*

18207. *Phthorophloeus frontalis.* May 16.
18231. *Dendroctonus valens.* Shack, June 5, May 16.
18276. *Hylastis porculus.* Shack, June 22.
18304. *Xyloterinus politus.* May 16.
18538. *Dryocoetes americanus.* Shack, June 21, August 24.

# DIPTERA

The greater part of the list of Diptera was prepared by Dr. O. A. Johannsen, but the Culicidae were listed by Dr. R. Matheson; the Syrphidae by H. B. Curran, R. C. Shannon and V. N. Argo; the Megaprosopidae, Phasmidae, Tachinidae, Dexiidae and Muscidae by Dr. L. S. West.

## Ptychopteridae

*Ptychoptera rufocincta.* S. Br., September 14.

*Bittacomorpha clavipes.* A. Br.; Bog 3, September. Larvae reported by Alexander from wet ground near Mud P.

## Anisopidae

*Anisopus punctatus.* Shack; Mud P.; Bog B, late August and September.

## Tipulidae

*Dicranomyia brevivena.* Mud P., September 23.

*D. halterata.* A. Br., September 16. Previously reported only from Fulton County.

*D. immodesta.* Hook; Mud P.; H. R., August to September.

*D. longipennis.* September 28, C. R. Crosby.

*Limonia immatura.* July 27, H. H. Knight; A. Br., September 12.

*L. solitaria.* W. R.; Bog 3, August 22.

*Helius flavipes.* Shack, August 31.

*Toxorhina muliebris.* July 3, A. D. MacGillivray.

*Antocha saxicola.* June 5, C. P. Alexander.

*A. opalizans.* Shack, June, July, August; A. Br., September 5.

*Ormosia deviata.* June 5, C. P. Alexander.

*O. innocens.* May 13. C. P. Alexander.

*O. meigenii.* Shack, May to June; Mud P., June 9.

*O. nigripila.* May 22, H. E. Schradieck; Shack, June 19.

*O. nubila.* May 13, C. P. Alexander.

*O. sp.,* female. Bog A, September 7.

*Erioptera chlorophylla.* Shack, July 10 and August 5.

*E. septemtrionis.* May 13 to June 5, C. P. Alexander; Shack, June, July, August 5.

*E. straminea.* Shack, June 21.

*E. vespertina.* Shack, August 31; Hook, September 3.

*E. armillaris.* June 5, C. P. Alexander.

*E. venusta.* I. Br.; Bog 2; Shack; W. R.; Hook, June to September.

*E. armata.* September 28, C. P. Alexander.

*E. caloptera* Say. June 5, C. P. Alexander; Shack, June 21.

*E. stigmatica.* September 28, H. H. Knight.

*Molophilus fultonensis.* Shack, August 7.

*M. hirtipennis.* June 5, C. P. Alexander; Shack, June 21; B. Cr., September 5.

*M. pubipennis.* Shack, August.

*M. ursinus.* I. Br., June 30.

*Gonomyia subsinerea.* Shack; I. Br., June.

*G. sulphurella.* Shack, August 31.

*Cladura flavoferruginea.* September 28, C. R. Crosby; A. Br.; H. R., September.

*Adelphomyia cayuga.* Shack, August 31.

*A. minuta.* June 5, C. P. Alexander; Mud P., June 5.

*Limnophila macrocera.* June 5, C. P. Alexander; B. Br., July 10.

*L. subtenuicornis.* May 31, C. P. Alexander.

*L. tenuicornis.* June 5, C. P. Alexander.

*L. fasciolata.* June 5, C. P. Alexander.

*L. adusta.* Bog C, August 20; Bog 3, September 7.

*L. brevifurca.* May 13 to June 5, C. P. Alexander.

*L. lutea.* May 31, F. Kahn.

*L. fuscovaria.* I. Br., June 30.

*L. subcostata.* S. Br., June 5.

*L. rufibasis.* June 5, C. P. Alexander; S. Br., June 5, 16.

*Pilaria recondita.* June 5, C. P. Alexander; Hook, August 24.

*P. tenuipes.* June 5, C. P. Alexander; Shack, July 7.

*Neolimnophila ultima.* Shack, August 31.

*Pseudolimnophila noveboracensis.* Shack, August 31.

*P. luteipennis.* Shack, August 23.

*P. toxoneura.* I. Br., June 30.

*Epiphragma fascipennis.* June 5, C. P. Alexander; S. Br., June 5.

*Ulomorpha pilosella.* June 5, C. P. Alexander.

*Eriocera tristis.* Mud P., July 25.

*Pedicia albovitta.* Shack, August 28; SE. Sl., September 16.

*Tricyphona autumnalis.* Reported hitherto only from northern counties. B. Cr., September 3.

*T. calcar.* May 22 to June 5, C. P. Alexander; S. Br., June 5.

*T. inconstans.* Shack, May 27, September 22, 23; A. Br., August 19; Hook, August 24.

*T. paludicae.* May.

*Oropeza obscura.* Shack, July 9.

*O. venosa.* June 5, C. P. Alexander.

*Nephrotoma ferruginea.* Shack, August 23, September 22; Bog A, August 26; Bog C, August 20; Bog 3, September 16.

*N. tenuis.* S. Br., August 19; Hook, August 24.

*Tipula unimaculata.* Hook, September 3.

*T. oropezoides.* May 22 to June 5, H. E. Schradieck; Shack, June 2, 9; S. Br., June 5; Mud P., June 11.

*T. abdominalis.* Shack, July 7, August 30, 31.

*T. bella.* W. R., August 22, 29.

*T. bicornis.* May 31, C. P. Alexander.

*T. caloptera.* June 5, C. P. Alexander.

*T. cunctans.* September 28, C. R. Crosby.

*T. dejecta.* Shack, May 27.

*T. fuliginosa.* June 5, C. P. Alexander.

*T. latipennis.* B. Cr., July 10; Hook, August 24.

*T. mingewe.* Shack, August 20, 21, 31, September 4.

*T. monticola.* June 5, C. P. Alexander.

*T. nobilis.* June 5, C. P. Alexander.

*T. sayi.* Bog A, August 28; Shack, September 21.

*T. senega.* June 5, C. P. Alexander; Shack, May 27; S. Br., June 5; Mud P., June 10.

*T. strepens.* June 5, C. P. Alexander.

*T. tephrocephala.* June 5, C. P. Alexander; Shack; Hook, July.

*T. tricolor.* Shack, August 30.

*T. trivittata.* Shack, June 18.

*T. ultima.* Shack; A. Br.; SE. Sl.; W. R., September.

### Dixidae

*Dixa fusca.* I. Br., September 13; Mud P., September 23.

*D. modesta.* May, October; T. 1.

### Psychodidae

*Psychoda cinerea.* Shack; Mud P.; I. Br., June to August.

### Chironomidae

*Ceratopogon fuscineris.* I. Br., June 30.

*C. peregrinus.* T. 9, 10, 13, 16.

*Forcipomyia specularis.* April, July, August.

*Euforcipomyia mutabilis.* T. 3, 13, 15.

*Culicoides biguttatus.* Shack, July.

*C. guttipennis.* Shack, June 22.

*C. sanguisuga.* T. 5.

*Heteromyia flavipes.*
*H. plebeia.* SE. Sl., August 20.
*H. trivialis.* July; T. 11.
*Palpomyia nebulosa.* July.
*Hartomyia mallochi.* I. Br., June 30; T. 5.
*Procladius pusillus.* Shack, July 24.
*Clinotanypus caliginosus.* Mud P., July 27.
*Tanypus decoloratus.* Bog 2, June 27.
*T. carneus.* T. 8, 9, 10.
*T. indecisa.* S. Br., August 13; T. 12.
*T. fastosa.* T. 2.
*T. florens.* July; T. 2.
*T. marginellus.* July.
*T. melanops.* July; T. 8, 9.
*T. monilis.* Mud P., August 24.
*Protenthes culiciformis.* Mud P.; A. Br., July.
*P. stellatus.* Shack, July 21.
*Trichotanypus persimilis.* April; T. 1.
*Prodiamesa notata.* I. Br., September 14. A rare northern species.
*Cardocladius obscura.* T. 9.
*Camptocladius fumosus.* T. 6.
*Orthocladius obumbratus.* April.
*O. nivoriundus.* T. 2.
*O. nigripilus.* T. 3.
*Trichocladius nitidus.* Bog B, July 24.
*Dactylocladius sordens.* July, rare.
*Cricotopus tremulus.* April; T. 8.
*C. bicinatus.* Mud P., September 14.
*Metriocnemus atratulus.* July; T. 6, 8.
*M. exagitans.* July; T. 7.
*M. flavifrons.* July; T. 8.
*M. knabi.* Bog B. The larvae of this species lives in the pitcher plant.
*M. lundbecki.* July; T. 1, 7, 10.
*Tanytarsus dives.* Shack, July 25; T. 1, 2, 3, 4, 5, 6, 7, 8, 10.
*T. fatigans.* July; T. 5, 8, 9.
*T. flavicauda.* I. Br., June 30.
*T. tenuis.* Mud P.; Shack, July, September; T. 1.
*Chironomus albimanus.* I. Br., June, August.
*C. aberrans.* S. Br.; Shack, July, August.
*C. cristatus.* Shack; Mud P., July to September.
*C. decorus.* Mud P., July, September.
*C. dux.* T. 8.

*C. fallax.* Shack, August, September.
*C. flavus.* Shack.
*C. flavicingula.* Shack; Mud P., May, August, September.
*C. lobiferus.* Shack; Mud P., July, August.
*C. maturus.* T. 3, 6.
*C. nigricans.* Mud P., July 27.
*C. pedellus.* Mud P., July, August.
*C. plumosus.* Shack; Mud P., June to September.
*C. taeniapennis.* Shack, June 21.
*Corynoneura celeripes.* July; T. 1, 9.

### Culicidae

*Chaoborus punctipennis.* August (R. M.). Larvae, probably of this species, found in Mud P.

*Anopheles punctipennis.* July.
*A. quadrimaculatus.* August.
*Wyeomyia smithii.* June to August. Larvae live in the pitcher plant.
*Culex testaceus.* July to August.
*Theobaldia dyari.* May to July.
*Aedes abserratus.* May.
*A. atropalpus.* July.
*A. canadensis.* May to August.
*A. cinereus.* May to August.
*A. excrucians.* May to July.
*A. fitchii.* May to August.
*A. intrudens.* July.
*A. lazarensis.* May.
*A. punctor.* May.
*A. stimulans.* April to August.
*A. triseriatus.* July.
*A. vexans.* September.

### Mycetophilidae

*Bolitophila hybrida.* Mud P., June 5.
*Diadocidea ferruginea.* SE. Sl., August 20.
*Asindulum montanum.* A. Br., September 20.
*Platyura diluta.* July.
*P. genualis.* June 24.
*Empalia tibialis.* Shack, July 30.
*Syntemna polyzona.* Hook, July 23.
*Neoempheria indulgens.* Hook, June 24.

*Diomonus magnificus.* B. Cr.; A. Br., August, September.
*D. pulchra.* B. Cr., August, September.
*Boletina sciarina.* SE. Sl., August 20.
*Leia opima.* S. Br.; Bog 3, June, September.
*L. sublunata.* Hook, September 3.
*L. winthemii.* Shack, September 22.
*Rhymosia captiosa.* A. Br., September 16.
*Phronia insulsa.* T. 9.
*Mycetophila foecunda.* A. Br., July.
*M. punctata.* S. Br.; A. Br., April, September.
*Delopsis anomala.* May.
*Sciara sciophila.* Generally distributed, July, August.
*S. ochrolabis.* August.
*S. pauciseta.* T. 4, 8.
*S. prolifica.* Shack, August 23.
*S. hastata.* Generally distributed, July to September. A rare species.
*S. coprophila.* Generally distributed, August to September.

### Bibionidae

*Plecia heteroptera.* Mud P., September 24.
*Bibio albipennis.* May.
*B. longipes.* Shack, August 26.
*B. pallipes.* May.
*Dilophus serraticollis.* S. Br., September 15.

### Simuliidae

*Simulium hirtipes.* I. Br.; Bog 2, June. Alpine species.
*S. venustum.* Shack, June 24.

### Tabanidae

*Chrysops carbonarius.* May.
*C. celer.* Bog B; Shack, June.
*C. cuclux.* May to July 3.
*C. fallax.* July.
*C. frigidus.* July, August. A northern species recorded also from New Jersey.
*C. indus.* June to September.
*C. niger.* May to July 3.
*C. obsoletus.* July to August.
*C. vittatus.* June, July.
*Tabanus astutus.* Bog A, July.
*T. bicolor.* Bog A, July, August.

*T. costalis.* June to August.
*T. lasiopthalmus.* May, June.
*T. lineola.* July.
*T. microcephala.* W. R., July, August.
*T. ohionensis.* July.
*T. pumilus.* June, July.
*T. trispilus.* July.

### Stratiomyiidae

*Allognosta fuscitarsis.* July.
*A. obscuriventris.* June.
*Actina viridis.* May; T. 3, 9, 14.
*Sargus cuprinus.* S. Br., September.
*S. decorus.* May to September.
*S. viridis.* May.
*Microchrysa polita.* June.
*Chrysogaster pulchella.* T. 8.
*Stratiomyia discalis.* May.
*S. norma.* Bog 3, August.
*S. quarternaria.* May.
*Odontomyia hydroleonoides.* July.
*O. interrupta.* June, July.
*O. pubescens.* May.
*O. virgo.* June.

### Rhagionidae

*Xylophagus lugens.* May.
*Atherix variegata.* May.
*Glutops singularis.* May (Liu). A rare northern species.
*Rhagio mystaceus.* May to July.
*R. plumbeus.* May.
*R. vertebratus.* July.
*Chrysopilus ornatus.* June.
*C. proximus.* May. Northern.
*C. quadratus.* July.
*C. thoracicus.* July.

### Acroceridae

*Ogcodes dispar.* Bog 2, September.
*Acrocera bimaculata.* Shack, August.
*A. fasciata.* Shack, June.
*A. nigrina.* Shack, June. A rare northern species.

### Bombyliidae

*Exoprosopa fascipennis.* July.
*Anthrax alternata.* B. Cr., August.
*A. fulviana.* A. Br.; B. Cr., September.
*A. lateralis.* July to August.
*Bombylius pygmaeus.* May.
*Sparnopolius fulvus.* August.

### Asilidae

*Dioctria albius.* June to July.
*Deromyia umbrina.* July.
*Dasyllis flavicollis.* May, July.
*D. sacrator.* July. Northern.
*Laphria canis.* A. Br., September.
*Asilus flavifemoratus.* July.
*A. notatus.* July.
*A. orphyne.* July.
*A. paropus.* Mud P., July, August.
*A. snowii.* July.
*A. sadytes.* August, September. Generally distributed.

### Dolichopodidae

*Psilopodinus banksi.* July.
*P. scintallans.* B. Cr., July.
*P. scobinator.* July.
*Diaphorus opacus.* June.
*Chrysotus affinis.* B. Cr., July.
*C. anomalus.* July.
*C. costalis.* July.
*C. discolor.* I. Br., July; T. 14.
*C. pallipes.* B. Cr., September.
*C. vulgaris.* July.
*Porphyrops melampus.* July; T. 14.
*Sympycnus lineatus.* August, September; T. 8.
*Xanthochlorus helvinus.* August.
*Dolichopus acuminatus.* May.
*D. adultus.* May.
*D. aequalis.* May.
*D. bifractus.* June, July.
*D. brevimanus.* May.
*D. comatus.* May, July to September; T. 11.

*D. cuprinus.* June to August.
*D. discifer.* May.
*D. detersus.* July.
*D. flavicoxa.* July.
*D. gratus.* May.
*D. laticornis.* June, July, September.
*D. lobatus.* T. 14.
*D. marginatus.* May.
*D. nodipennis.* June.
*D. ornatipennis.* Mud P., July. A rare northern species.
*D. ramifer.* May, June.
*D. remus.* H. R., June.
*D. scoparius.* June.
*D. socius.* May.
*D. setifer.* August, September.
*D. trisetosa.* A. Br.; Mud P., June, July.
*D. variabilis.* September.
*Gymnopterus barbatulus.* July.
*G. crassicauda.* June.
*G. difficilis.* May.
*G. frequens.* June, August.
*G. humilis.* May.
*G. opacus.* Shack; I. Br., June, July.
*G. spectabilis.* S. Br.; Bog 3, June.
*G. subulatus.* B. Cr., August.
*Tachytrechus binodatus.* Mud P., July.
*T. vorax.* Mud P., July.
*Pelastoneurus vagans.* July, September.

### Empididae

*Platypalpus discifer.* S. Br., July.
*P. lateralis.* I. Br., June.
*Hemerodromia notata.* I. Br., September.
*Clinocera maculata.* I. Br., September.
*Syneches simplex.* Bog A, July.
*S. thoracicus.* June.
*Hypos slossonae.* August to September. Generally distributed.
*H. triplex.* Bog 3; S. Br., June, July.
*Leptopeza compta.* Shack, June.
*Ocydromia glabricula.* June, August, September.
*Hilara gracilis.* Shack, August.

*H. macroptera.* Shack, June.
*H. tristis.* I. Br., June.
*Cyrtoma femoratus.* S. Br., June.
*C. longipes.* B. Cr., July.
*Rhamphomyia gracilis.* August, September. Generally distributed.
*R. mutabilis.* Bog 3, September.
*R. pulla.* S. Br.; Shack, June.

### Phoridae

*Dohrniphora nitidifrons.* S. Br.; A. Br., July, September.
*Hypocera flavimana.* A. Br., April to September.
*Phora aterrima.* S. Br., September.
*Aphiochaeta stramipes.* April.
*A. rufipes.* T. 4, 6.
*Gymnophora quartomollis.* S. Br., July.

### Platypezidae

*Agathomyia perplexa.* S. Br., September.
*A. canadensis.* W. R., August.
*A. vanduzeei.* Bog 1, September.
*Platypeza velutina.* August, September.
*P. anthrax.* July, September.

### Pipunculidae

*Pipunculus atlanticus.* A. Br., September.
*P. cingulatus.* September.
*P. femoratus.* T. 8.
*P. horvarthi.* S. Br., September.
*P. houghi.* A. Br., September.

### Syrphidae

*Platychirus quadratus.* May, June, July.
*Melanostoma obscurum.* September.
*Syrphus wiedemanni.* July.
*S. rectus.* A. Br., September.
*S. torvus.* September.
*Chalcomyia aerea.* May.
*Xanthogramma flavipes.* September.
*X. emarginata.* September.

*Mesogramma marginata.* July, September.
*M. polita.* September.
*Toxomerus marginatus.* July.
*T. geminatus.* August, September.
*Sphaerophora cylindrica.* May, August.
*S. sp.* July to September.
*Microdon fuscipennis.* May, August.
*Epistrophe grossulariae.* September.
*E. grossulariae-melanis.* September.
*E. cinctellus.* September.
*Cnemodon calcarata.* July, September.
*Chrysogaster nitida.* August, September.
*C. pulchella.* May, June, August, September.
*C. nigripes.* May.
*Paragus bicolor.* June.
*Cartosyrphus cyanesceus.* June.
*C. pallipes.* August.
*Heryngia salax.* September.
*Chilosia orilliaensis.* May, August.
*Rhingia nasica.* May, September.
*Sericomyia chrysotoxoides.* May, August, September.
*S. militaris.* September.
*Chrysotoxum plumeum.* September.
*Eristalis arbustorum.* July, September.
*E. bastardi.* May, June, July, September.
*E. compactus.* May.
*E. flavipes.* July.
*E. saxorum.* May.
*E. transversus.* June.
*E. dimidiatus.* September.
*E. tenax.* August, September.
*Tropidea quadrata.* August, September.
*Helophilus bilinearis.* April, May.
*H. latifrons.* September.
*H. laetus.* July.
*H. similis.* September.
*H. stipates.* July.
*H. conostomus.* June, July.
*Syritta pipiens.* August.
*Xylota chalybea.* June.
*X. fraudulosa.* July.
*X. angustiventris.* August.

*Cynorrhina analis.* May, June.
*Temnostoma alternans.* July.
*T. bombylans.* May to September.
*T. excentricum.* June.
*Spilomyia fusca.* September.
*S. 4-fasciata.* August.

### Conopidae

*Zodion fulvifrons.* May, June.
*Occemyia abbreviata.* July.
*Myopa vesiculosa.* June.
*M. virginica.* June. Southern.

### Cordyluridae

*Orthochaeta amoena.* June.
*Paralleloma gracilipes.* September.
*P. pleuritica.* May, August, September.
*P. slossonae.* May.
*Achaetella veripes* (bimaculata Lw.) A. Br., May, August, September.
*Cordylura confusa.* June, July.
*C. gagatina.* May to July.
*C. gilvipes.* T. 8.
*C. praeusta.* May, September.
*C. terminalis.* July.
*Megophthalma lutea.* S. Br., September.
*Scatophaga furcata.* May.
*S. nigrolimbata.* June, August, September.
*S. stercoraria.* May to September; T. 8.

### Heteroneuridae

*Clusia czernyi.* May.

### Helomyzidae

*Helomyza plumata.* September.
*Scoliocentra helvola.* September.

### Borboridae

*Borborus equinus.* July, August. Generally distributed.
*Leptocera frontinalis.* Mud P.; I. Br., July.
*L. lutosa.* July.
*Scatophora carolinensis.* S. Br., May, July.

### Tetanoceridae (Sciomyzidae)

*Neuroctena analis.* June to September.
*N. simplex.* August, September.
*Poecilographa decora.* June, July.
*Pteromicra nigromana.* Bog 3, August.
*Dictyomyia ambigua.* September. Generally distributed. A northern species.
*Euthycera arcuata.* B. Cr., August, September.
*Limnia boscii* (=combinata Lw.). June, July.
*L. boscii* var. *sparsa.* B. Cr., September.
*L. saratogensis.* June, July.
*Tetanocera plebeia.* Bog 3, September.
*T. valida.* Bog 1, September 14.
*T. vicina* (plumosa Lw.). Bog 3, June, August, September.
*Sepedon pusillus.* Bog 3, September 15.

### Sapromyzidae (=Lauxanidae)

*Lauxania cylindricornis.* May, July; T. 8.
*Melanomyza gracilipes.* August, September.
*Minettia lupulina.* June, September.
*M. obscura.* August, September.
*Sapromyza quadrilineata.* June, July.
*Sapromyzosoma fraterna.* August, September. Generally distributed.
*S. conjuncta.* July.
*S. incerta.* Bog C, August 20.
*S. philadelphica.* July to September.
*S. sheldoni.* July. Northern.

### Ortalidae

*Pyrgota undata.* June.
*Chaetopsis massyla.* July.

### Trypetidae

*Aciura nigricornis.* May. A rare species.
*Rhagoletis pomonella.* September.
*Eutreta sparsa.* August, September.
*Euaresta bella.* August.
*Euribia albiceps.* June, July.

### Sepsidae

*Sepsis neocynipsia.* June.
*S. pectoralis.* July, August.
*S. signifera.* July.

*S. signifera* var. *curvitibia.* July.
*S. violacea.* June to September; T. 5.
*Nemopoda cylindrica.* September.
*Themira minor.* July.

### Psilidae

*Loxocera cylindrica* var. *pleuritica.* July, September.
*Pseudopsila fallax.* Bog 3, September 7. Northern.
*Psila frontalis.* W. R.; A. Br., August, September. Northern.

### Ephydridae

*Notiphila scalaris.* Bog 1, September 14.
*Parydra bituberculata.* July, September.
*Scatella lugens.* June.

### Chloropidae

*Chloropisca glabra.* May.
*Diplotoxa microcera.* August.
*Chlorops obscuricornis.* A. Br., June 28.
*C. producta.* June, July.
*Anthracophaga sanguinolenta.* May.
*Hippelates plebeius.* Bog A, August 20. Southern.
*Crassiseta costata.* July.
*C. fusciceps.* T. 14.
*C. nigriceps.* June.
*Botanobia anthracina.* Bog A, July 26.
*B. coxendix.* April, July, August.
*B. coxendix* var. *obscura.* August.
*B. incerta.* S. Br., July 12.
*B. variabilis.* May.

### Drosophilidae

*Chrymomyza amoena.* May.
*Scaptomyza graminum.* SE. Sl., August 20.
*Drosophila quinaria.* May, September.
*D. melanogaster.* Shack, August 31.

### Agromyzidae

*Ochthiphila polystigma.* B. Cr., May, July, September.
*Agromyza angulata.* Bog 2, September 16.
*A. jucunda.* Mud P.; Bog 3, July, September.
*A. laterella.* T. 8.

*A. marginata.* July; T. 8.
*A. virens.* September.
*Diastata repleta.* Bog B, May, July.
*D. pulchella.* T. 10.
*Ishnomyia spinosa.* Bog 1, September 14.
*Anthomyza variegata.* I. Br., July 2.
*Mumetopia nitens.*
*M. terminalis.* I. Br., June 30.
*Phytomyza bipunctata.* S. Br., September 14.

### Anthomyiidae

*Schoenomyza chrysostoma.* June, July.
*Macrorchis ausoba.* May, July, August, September.
*Coenosia flavifrons.* July, September. Reported from Georgia.
*C. geniculata.* July.
*C. lata.* August.
*C. triseta.* T. 15.
*Eustalomyia festiva* (brixia Walk.). B. Cr., September 20.
*Hylemyia aureispicuus.* S. Br., June 23.
*H. antiqua.* May, July to September.
*H. alcathoe.* August, September.
*H. brassicae.* July.
*H. cilicrura.* S. Br., May, September 15.
*H. fuscipennis.* May.
*H. innocua.* August.
*H. inornata.* May to September.
*H. laevis.* July.
*H. pluvialis.* July to September.
*H. setitarsata.* May.
*H. trichodactyla.* May, July.
*H. variata.* T. 15.
*Pegomyia affinis.* May, August, September.
*P. bicolor.* W. R.; B. Cr., August, September.
*P. dissecta.* May, July.
*P. lipsia.* September.
*P. unicolor.* July.
*P. winthemi.* August, September.
*Anthomyia pluvialis.* Bog A, August 17.
*Hydrophora ambigua.* Mud P., July 23.
*H. divisa.* S. Br., August 19.
*H. uniformis.* Mud P.; Bog B, September.

*Paregle cinerella.* September.
*P. radicum.* August, September.
*Fannia manicata.* Bog A, August.
*Lispocephala erythrocephala.* July to September.
*Lispa uliginosa.* Mud P., August.
*Pentacricia aldrichi.* May. Rare. T. 8.
*Hebecnema umbratica.* August.
*Limnophora aequifrons.* September.
*L. discreta.* Mud P., July, August.
*L. monticola.* Mud P., September 23.
*Mydaea* (Aricia) *lucorum.* June, July, September; T. 15.
*M.* (Aricia) *lysinoe.* May, August, September.
*M.* (Aricia) *pectinata.* Shack, June, July.
*M. urbana.* Mud P.; Hook, May to September 24.
*Muscina assimilis.* July, August.
*Dialyta flavitibia.* B. Cr.; Mud P., July, September. Rare.
*Hydrotaea houghi.* Bog A, August 10.
*H. militaris.* May to September.
*H. metatarsata.* June.
*H. unispinosa.* May to July, September; T. 15.
*Ophyra leucostoma.* August, September.
*Phaonia apicata.* July, September.
*P. deleta.* Bog A, August.
*P. errans.* Shack; SE. Sl., September.
*P. nigricans.* Bog A, May, August.
*P. serva.* May.

### Megaprosopidae

*Micropthalma phyllophagae.* Bog 2, August.

### Phasiidae

*Cistogaster immaculata.* May to September.
*Gymnosoma fuliginosa.* August, September. Generally distributed.
*Euphorantha diversa.* B. Cr., September 16. Hitherto reported only from Adirondacks.
*Phasia nitida.* S. Br., July 1.
*P. furva.* August, September.
*P. brevineura.* Bog 3, September 7.
*P. fumosa.* September.

TACHINIDAE

*Emphanopteryx prisca.* June.
*Actia pilipennis.* September.
*Actiopsis autumnalis.* August.
*Lixophaga variabilis.* September.
*Methypostena barbata.* June to July.
*Tachinophyto maculosa.* September.
*Polidea areos.* August to September.
*Hyalomyodes triangulifera lotus.* B. Cr.; A. Br.; S. Br., September.
*Siphophyto floridensis.* August.
*Siphona geniculata.* May.
*Cyrtophloeba horrida.* May; T. 1, 10.
*Triachora unifasciata.* May.
*Aphria ocypterata.* May, July.
*Cylindromyia carolinae.* July.
*Bonnetia comta.* Bog A, July to August.
*Nemorilla maculosa.* September.
*Zenillia reclinata.* September.
*Z. caesar.* September.
*Z. crassiseta.* September.
*Z. vulgaris.* September.
*Z. confinis.* September.
*Z. blanda.* July to September.
*Z. blandita.* July.
*Z. futilis.* July, September.
*Phorocera leucaniae.* July.
*Blepharipeza leucophrys.* May to September.
*B. sp.* Bog 3, September 12.
*Winthemia fumiferanae.* July.
*W. quadripustulata.* August, September. Generally distributed.
*Metachaeta atra.* July, August.
*Acemyia dentata.* May.
*Exorista larvarum.* August.
*Chaetotachina simulans.* July, September.
*Tachinomyia robusta.* April.
*Phorichaeta sequax.* May.
*Eugaediopsis ocellaris.* A. Br.; Hook, August, September.
*Chaetogaedia analis.* August, September. Generally distributed.
*Peleteria anaxias.* August, September. Generally distributed.
*P. confusa.* July to September.
*P. iterens.* July to September.
*Archytas analis.* Bog 3; B. Cr., August September.

*Fabriciella dakotensis.* Bog B, August 31.
*Bombyliopsis abrupta.* August, September. Generally distributed.
*Jurinia decisa.* B. Cr., August to September.

### Dexiidae

*Rhynchodexia confusa.* August, September. Generally distributed.
*R. translucipennis.* July.
*Dexia vertebrata.* July.
*Thelaira nigripes.* S. Br., July to September 15.
*Spathidexia dunningi.* June.

### Saracophagidae

*Metopia campestris.* May to September.
*M. leucocephala.* July to August.
*Sarcophaga communis.* June.
*S. peniculata.* June.
*S. cimbicis.* June.
*S. sinuata.* June.
*S. helicis.* June.
*S. dux sarracenioides.* June, July. The larvae of this species lives in the leaves of the pitcher plant.

### Muscidae

*Stomoxys calcitrans.* August, September. Generally distributed.
*Lyperosia irritans.* Bog 3, September.
*Musca domestica.* August, September.
*Pyrellia cyanicolor.* August, September. Generally distributed.
*Graphomyia maculata.* August, September; T. 15.
*Muscina assimilis.* August. Taken at carrion.
*M. stabulans.* August.
*Myiospila meditabunda.* August. Taken at carrion.
*Morellia micans.* July.

### Calliphoridae

*Protocalliphora splendida* form sialis. June.
*Cynomyia cadaverina.* August.
*Calliphora erythrocephala.* August.
*C. vomitoria.* August.
*Lucilia caesar.* August.
*Pollenia rudis.* August, September. Generally distributed.

# HYMENOPTERA

List Compiled by J. Chester Bradley

The collecting upon which the list of this order was based is largely that done by Dr. C. K. Sibley during the summer of 1924, and Mr. S. Robinson during the summer of 1925, with such of the material from previous seasons accumulated in the collections of Cornell University, as time available has made it feasible to include. There has been no particular collecting of the insects of this order with a view to relating them to their immediate environment and economy within the life of the bogs.

Our thanks are extended to several persons whose prompt responses to a hurried request for identifications has made the list possible. Mr. C. F. W. Muesebeck has determined the Braconidae, Dr. M. M. Wheeler the ants, Mr. S. A. Rohwer the bees, except Bombidae and Osmiae, Miss Grace Sandhouse the Osmiae, Mr. A. B. Gahan the Chalcidoidea, Mr. Robert M. Fouts the Serphoidea, and Mr. R. A. Cushman a considerable portion of the Ichneumonidae. The balance of the Ichneumonidae and the other families have been determined by the compiler.

This list enumerates approximately four hundred species distributed among thirty families.

### Siricidae

*Urocerus cressoni.* The Shack, August 24. Larvae bore in conifers.
*Tremex columba.* West Ridge, August 29. Larvae bore in hardwoods.

### Cimbicidae

*Cimbex americana.* Grass Bog 3, June 19; Beaver Brook, July 25.
*Trichiosoma spicatum.* June 13.

### Argidae

*Arge macleayi.* May 30.
*A. clavicornis.* July 9.
*Acordulecera maculata.* July.
*A. mixta.* Mud Creek, June 17.

### Tenthredinidae

*Strongylogastroidea apicalis.* August 3.
*S. epicera.* Mud Pond, June 9.
*S. rufocincta.* July 18.
*Taxonus nigrisoma.* June, July.
*Macremphytus versicolor.* Grass Bog 1, September.
*Amastegia glabrata.*
*Parataxonus multicolor.* The Shack, June 20.

*Monosoma inferentia.* May.

*Loderus albifrons.* May.

*Bivena delta.* April 3, May 31.

*Macrophya albomaculata.* May.

*M. flavicoxa.* May; Argus Brook, July 20.

*M. trisyllaba.* Hemlock Ridge, September 24; The Shack, August 4; Sphaerium Brook, June 12.

*M. varia.* June, July 19; Sphaerium Brook, June 12.

*M. zonalis.*

*Tenthredo basilaris,* (*Allantus*). Beaver Brook, August 30 to September 3; Bog B, August 19; Grass Bog 1, September.

*T. dubius.* July 18.

*Tenthredella grandis,* (*Tenthredo*). May.

*T. rufopecta.* May 29.

*T. rufipes.* May 31.

*T. signata.* May 31.

*Monophadnus tilliae.* May.

*Neotomostethus hyalinus.* The type.

*Tomostethus* (*Atomostethus*) *inhabilis.* Sphaerium Brook, June 13; The Hook, July 15.

*Hemitaxonus dubitatus.* May.

*Strongylogaster longulus.* The Hook, June 5.

*S. politus.* The Hook, June 5.

*S. tacitus.* April 30.

*Hemichroa americana.* May.

*Hoplocampa halcyon.* May.

*Pachynematus aurantiacus.*

*P. corniger.* The Hook, June; West Ridge, August.

### Braconidae

*Microbracon gelechiae.* August 1.

*M. pygmaeus.* Beaver Creek, September 1.

*M. lutus.* S. E. Slope, August 12.

*M. variabilis.* The Hook, June 5.

*Bucculatriplex sp.* August 11.

*Rogas abdominalis.* Grass Bog 1, August 11.

*R. aciculatus.* The Shack, June 24.

*R. canadensis.* Inlet Brook, August 31; Beaver Creek, September 1.

*Ascogaster sp.* Inlet Brook, June 30; S. E. Slope, August 12; Grass Bog 3, August 22.

*Schizoprymnus sp.* August 31.

*Microgaster carinata.* Grass Bog 2, August 31.

*Microplitis confusus.* May 30.

*M. sp.* Trillium Grove, August 31.

*Apanteles cinctiformis.* Sphaerium Brook, July 12; Grass Bog 3, July 15; Inlet Brook, June 30.

*A. consimilis.*

*A. crassicornis.* Beaver Creek, August 1.

*A. euphydryidis.* May. A parasite of *Euphydryas phaeton.*

*A. femur-rubrum.* July.

*A. ornigis.* West Ridge, August 17.

*A. polychrosidis.*

*A. rohweri.* The Hook, August 31.

*Bassus bicolor.* Grass Bog 3, September 19.

*B. calcaratus.* Grass Bog 3, September 19.

*B. cinctus.* Beaver Creek, August 1.

*B. perforator.* Grass Bog 3, August 22.

*Earinus limitarsis.* April 17.

*Blacus sp.* Inlet Brook, August 31; The Shack, September 14.

*Orgilus sp.* Beaver Creek, August 1.

*Eubadizon pleuralis.* The Shack, June 24.

*Ichneutes fulvipes.* S. E. Slope, August 12.

*Macrocentrus plesius.* The Shack, June 24 to August 23.

*M. pyraustae.* S. E. Slope, August 20; Grass Bog 3, August 22.

*Opius fuscipennis.* August 19.

*O. provancheri.* The Hook, August 31.

*Meteorus hyphantriae.* Grass Bog, September 16.

*M. politus.* Bog B, August 28; Trillium Grove, August 31.

*M. tauricornis.* Beaver Creek, August 26; Inlet Brook, August.

*M. trachynotus.* Argus Brook, July 20; The Hook, August 24.

*M. vulgaris.* Beaver Creek and The Shack, July 10; Bog C, August 2.

*Coelonidea sp.* Sphaerium Brook, July 12; Inlet Brook, July 2.

*C. sp.* Grass Bog 3, July 15.

### Ichneumonidae

*Trachichneumon confirmatus.* S. E. Slope, September 16.

*Amblyteles acerbus.* May 30; Bog A, August 26; Bog B, August 30; Grass Bog 1, August 31; Grass Bog 3, September 16; West Ridge, September 23; Mud Pond, September 24; Trillium Grove, August 20.

*A. annulipes.* The Hook, September 3; Argus Brook, September 4.

*A. brevicinctor, (extrematis).* May; Grass Bog 1, August 31; Bog B, August 28.

*A. centrator.* April 17; Sphaerium Brook, June 20.

*A. comes.* July 11 to 25.

*A. devinctor.* April 17.

*A. duplicatus.* July 25; Grass Bog 1, September 17; Grass Bog 2, August 23 to 31; Grass Bog 3, August 22; Hemlock Ridge, August 31; Beaver Brook, August 30; S. E. Slope, September 16.

*A. finitimus.* Grass Bog 3, August 22.

*A. funestus.* The Shack, August 30.

*A. fuscifrons.* S. E. Slope, September 16.

*A. galenus.* July.

*A. germanus.* S. E. Slope, August 12.

*A. grandis.* Beaver Creek, September 3.

*A. improvisus.* The Shack, August 26; Argus Brook, September 4.

*A. lachrymans.* Beaver Creek, July 25; Bog B, August 19.

*A. laetus.* July; Sphaerium Brook, September 20; The Hook, August 31; Bog A, August 26; Grass Bog 3, September 7 to 19; Beaver Creek, September 13; Hemlock Ridge, August 6; Argus Brook, September 19; West Ridge, August 29.

*A. malacus.* Beaver Brook, August 30; Argus Brook, September 20.

*A. milvus.* The Hook, August 31; Beaver Creek, September 1.

*A. munificus.* The Hook, September 3.

*A. orpheus.* The Hook, August 25.

*A. paratus.* West Ridge, August 22; The Hook, August 24 to September 3.

*A. parvus.* The Hook, September 3; Sphaerium Brook, June 13; Beaver Brook, September 1.

*A. quebecensis.* June 30 to July 11.

*A. stygicus.* July 18.

*A. sublatus, (pravus,* ♀ ). Argus Brook, ♀, September 20; Mud Pond, ♀, September 24; Sphaerium Brook, ♂, July 28; West Ridge, ♂, August 29.

*A. succinctus.* July.

*A. unifasciatorius.* Beaver Creek, September 21; Sphaerium Brook, September 15; Hemlock Ridge, September 12; The Hook, August 24; Argus Brook, September 4; Grass Bog 1, August 11.

*A. w-album.* The Hook, August 24; Grass Bog, September 3.

*Herpestomus sp.* Bog B, August 18.

*Eparces quadriceps, (Phaeogenes).* Argus Brook, September 17.

*Phaeogenes hebrus.* April 17.

*P. spp.* July 17 to September 6; Grass Bog 1; West Ridge.

*Mesoleptus sp.*

*Atractodes sp.* West Ridge, August 17.

*Thysiotorus smithi.* August 18; S. E. Slope, September 16; Hemlock Ridge, August 20, 1925.

*Stylocryptus inflatus.* August 18.

*S. pubescens.* August 1.

*S. sp.* Beaver Creek, August 1, 1925.

*Phygadeuon brevicornis.* Beaver Creek, September 14.

*P. orbitalis.* Grass Bog 1, September 17.

*Polytribax pallescens.* S. E. Slope, September 16, 1924.

*Hemiteles ruficoxis.* Beaver Creek, August 26, 1925.

*H. sp.* July 26; Grass Bog 3, September 7.

*Gelis bucculatricis.* S. E. Slope, September 16.

*G. urbanus.* April 17.

*G. sp.* Beaver Brook, August 1.

*Acroricnus junceus.* Beaver Brook, August 30.

*Spilocryptus atricollaris.* July 25; S. E. Slope, September 12.

*S. canadensis.* Grass Bog 2, August 31.

*S. nuncius.* Grass Bog 3, August 23; Beaver Brook, August 30.

*S. sp.* Grass Bog 3, August 27.

*Megaplectes monticola, (blakei).* June 30, 1921.

*Chaeretymna spp.* Grass Bog 3, September 4 to 7.

*Exetastes suavolens.* The Hook, August 24; Argus Brook, July 20.

*Lissonota (Lissonota) americana.* July 18; Beaver Creek, August 1.

*L. (L.) jocosa.* S. E. Slope, August 22.

*L. (L.) laevigata.* Grass Bogs 1 and 3, August 31 to September 17.

*L. (L.) parva.* West Ridge, August 17 to 22; S. E. Slope, August 20; The Hook, September 3.

*L. (L.) varia.* Beaver Creek, September 1; Hemlock Ridge, September 24.

*L. (Asphragis) mirabilis, (Meniscus).* Bog B, August 7.

*Cylloceria occidentalis.* July 20; Beaver Creek, July 25; Hemlock Ridge, September 24.

*Glypta canadensis.* August 1.

*G. phoxopteridis.* The Hook, August 31, 1925.

*G. sp.* Trillium Grove and Beaver Creek, August 31; Grass Bog 1, September 14.

*Phytodietus burgessi.* May; Argus Brook, July 20, 1924.

*P. vulgaris.* Grass Bog 3, August 22.

*Theronia melanocephala.* Argus Brook, September 4; S. E. Slope, August 20.

*Ephialtes (Ephialtes) aequalis, (Pimpla).* Grass Bog 2, June 27; Argus Brook, June 23; The Hook, August 19 to September 3; Hemlock Ridge, August 31.

*E. pedalis.* Argus Brook, September 4 to 19; The Hook, June 18 to August 24.

*E. tenuicornis.* May; The Hook, August 19 to September 3; S. E. Slope, August 20 to September 16; West Ridge, August 7; The Shack, June 24; Sphaerium Brook, June 23, 1924.

*E. (Itoplectis) conquisitor.* July.

*E. (Tromatobia) scriptifrons.* May 29.

*Apechthis picticornis, (Pimpla).* The Hook, August 31; S. E. Slope, August 20.

*Polysphincta (Polysphincta) strigis.* Beaver Brook, August 26, 1925.
*P. (P.) texana.* Hemlock Ridge, August 24.
*P. (Zatypota) crosbyi.* November.
*Polemophthorus sp.* Beaver Brook, August 25.
*Rhysella nitida.* May; West Ridge, August 17.
*Odontomerus canadensis.* Hemlock Ridge, August 31.
*O. dichrous.* May 29; Beaver Creek, September 14.
*O. mellipes.* The Shack, August 8.
*O. vicinus.* May 31; Beaver Creek, September 21.
*Ichneumon (Ichneumon) irritator, (Ephialtes).* May; Hemlock Ridge, June 23.
*I. (I.) tuberculatus.* Grass Bog 3, August 27.
*Scambus (Iseropus) coelebs, (Pimpla).* August 3; Trillium Grove, August 31.
*S. (Epiurus) pterophori, (pterelas).* Bog B, August 24 and September.
*S. (E.) tecumseh.* The Shack, August 26, 1924.
*S. (E.) spp.* August 7.
*Zaglyptus incompletus.* Mud Pond, August 30.
*Euceros canadensis.* May 29.
*E. cooperi.* May 29.
*E. medialis.* June 30.
*E. thoracicus.* May 31.
*Neliopisthus densatus.* August 18; Beaver Brook, August 1, 1925.
*Ctenopelma sp.* Mud Pond, June 9.
*Notopygus sp.*
*Hadrodactylus elongatus* var. *femoratus.* Sphaerium Brook, July 1.
*Opheltes glaucopterus.* Beaver Creek, August 30.
*Absyrtus spp.* The Shack, August 28.
*Alexeter riparius.* June 30, 1921.
*A. seminiger.* June 30.
*A. sp.* August 1, 1925.
*Mesoleius convergens.* May.
*M. mellipes.* Beaver Brook, August 1.
*M. submarginatus.* Grass Bog 3, August 27.
*Spanotecnus concolor.* May; The Hook, June 5.
*S. discolor.* The Shack, June 18.
*Spudaea sp.* Grass Bog 1, September 6.
*Tryphon communis.* May.
*Scorpiorus analis.* Trillium Grove, August 31; Argus Brook, September 20.
*Exyston clavatus.* June.
*Paniscus leo.* The Shack, August 31.
*Parabates smithi.* Trillium Grove, August 31.
*Diplazon laetatorius.* May.

*Homotropus bicapillaris* var. *albopictus*. Argus Brook, June 18.

*Syrphoctonus agilis*. May.

*Promethes costalis*. May to July.

*S. minimus, (pacificus)*. May.

*Zootrephes compressiventris*. May.

*Tapinops pusilla*. August 17; Grass Bog 1, September 20; Inlet Brook, September 3.

*Exochus dorsalis*. Grass Bog 3, September 12.

*E. pallipes*. May; S. E. Slope, August 12.

*Triclistus curvator*. April 31; Inlet Brook, August 7, 1925.

*T. propinquus*. May; Bog C, August 20.

*Enicospilus purgatus*. Hemlock Ridge, August 19; Argus Brook, September 4; The Shack, August 21; Bog C, August 20.

*Eremotylus macrurus*. Argus Brook, September 16; The Shack, September 12.

*Ophion bifoveolatum*.

*O. bilineatum*. The Shack, June 30 to September 22; Bog A, June 12; Mud Pond, June 29.

*Thyreodon atricolor, (morio, brullei)*. Mud Pond, August 11; Bog A, August 27; Grass Bog 3, September 11.

*Agrypon chlamidatum*.

*Heteropelma flavicorne*. Bog B, August 28. A parasite of Datana.

*Labrorychus analis*. July 18; Grass Bog 3, September 7.

*L. sp*. Beaver Creek, August 1.

*Paranomalon sp*. Bog B, August 7.

*Therion fuscipenne*. July 20; Grass Bog 3, August 20.

*T. hyaline*. June 30.

*T. morio*. Grass Bog 3, September 7; Argus Brook, July 20.

*Therion hyaline*. June 30.

*Campoplegidea argentea*. Hemlock Ridge, August 31.

*Viereckiana bellulus*. Bog A, August 26.

*V. brachiator*. August 18; The Shack, August 24.

*V. vitticollis*. Bog A, August 28.

*Hyposoter geometrae*. Beaver Creek, August 1.

*H. pilosulus*. Beaver Creek, August 1.

*Sagaritis oxylus*. Grass Bog 1, August 11.

*S. sp*. The Shack, August 1.

*Olesicampe sp*. Argus Brook; Grass Bog 1; Trillium Grove, July 20 to September 19.

*Nepiera sp*. Sphaerium Brook, July 12.

*Campoplex ferrugineipes*. Argus Brook, September 19.

*C. spp*. (4).

*Echthronomas ochreofrons.*
*Cremastus (Cremastus) graciliventris.* The Shack, August 28.
*Megastylus sp.* Bog B, August 30.
*Aperileptus clypeatus.* Beaver Creek, August 25.
*A. sp.* Hemlock Ridge, August 31.
*Diacritus muliebris.* West Ridge, August 7; S. E. Slope, September 16.
*? Helictes sp.* Hemlock Ridge, August 31.
*Proclitus sp.* Hemlock Ridge, August 31.
*Banchus ferrugineus?* May 25.
*Mesochorus sp.* West Ridge, August 29.

### Aulacidae

*Pammegischia burquei.* June 31. A rare parasite of the wood boring larvae of the horn-tail Xiphydria.

### Pelecinidae

*Pelecinus polyturator.* Beaver Creek. August 19 to 31.

### Diapriidae

**Aparamesius nigriclaris.* May 16, 1925. M. D. Leonard.
*Aneurrhynchus mellipes.* Hemlock Ridge, August 31.
**Xenotoma antennalis.* August 20.
**X. pilosa.* Inlet Brook, August 31.
**X. palustra.* August 17.
**X. curvicaudis.* The Hook, August 19.
**Aclista palustra.* July 26.
**A. excavata.* July 26; Hemlock Ridge, August 31; West Ridge, August.
**A. obliterata.* Hemlock Ridge, August 31.
**A. simulans.* July 26.
**Belyta rugifrons.* Hemlock Ridge, August 19.
*Phaenopria aptera.* May 16. M. D. Leonard.

### Platygasteridae

*Platygaster sp.* April 26.

### Callimomidae

*Callimome sp.* August 18; The Shack, August 9.
*Cryptopristus sp.* Bog B, August 19.

### Perilampidae

*Perilampus sp.* Bog B, August 19.

---

* These ten species will shortly be described by Mr. Robert Fouts.

### Chalcididae

*Leucospis affinis.* Grass Bog 3, August 19.

### Encyrtidae

*Encyrtus marylandicus* var. *alpinus.* Beaver Creek.

### Pteromalidae

*Zatropis sp.* August 19.

### Cleonymidae

*Trigonoderus unguttatus.* West Ridge, August 17.
*T. n. sp.*
*T. spp.* (3). S. E. Slope.

### Eulophidae

*Comedo orgyiae.* August 19.
*Secodella sp.* Beaver Creek, August 1.
*Tetrastichus spp.* (6).
*Pleurotropis sp.* August 13.

### Psammocharidae

*Episyron biguttatus.* July 9; The Shack, August 17.

*Psammochares (Lophopompilus) aethiops.* July 18; Beaver Creek, September 14.

*P. (Anoplius) illinoiensis.* July 18; Hemlock Ridge, September 12; Bog B, August 28; Grass Bog 3, September 7; Bog A, August 23.

*P. (A.) tenebrosus.* July.

*P. (A.) virginiensis.* July; S. E. Slope, August 12.

*P. (Pompiloides) cylindricus.* July 18; Mud Pond, September 24.

*P. (P.) reducta.* July 18.

*P. (Nannopompilus) argenteus.* July 18.

*Pseudagenia varitarsata.* The Shack, August 23 to 31.

*Priocnemis conicus.* May.

*Ceropales fraterna.* July 18.

*C. robertsoni.* July, on Cicuta maculata.

### Chrysididae

*Holophris iridescens.* Argus Brook.

*Chrysis (Tetrachrysis) nitidula.* Hemlock Ridge, August 18; The Shack, June 21 to August 13. Det. L. H. Taylor.

*C. (T.) caerulans.* The Shack, June 19 and August 13; Hemlock Ridge, August 31. Det. L. H. Taylor.

*C. (T.) cessata.* The Shack, June 20. Det. by L. H. Taylor.

### Tiphiidae

*Myrmosa unicolor.* August.

### Mutillidae

*Pseudomethoca canadensis.* August.

### Formicidae

*Crematogaster lineolata.* Beaver Creek.

*Aphaenogaster tennesseensis.* S. E. Slope, in decayed logs.

*A. fulva* subsp. *aquia.* The Hook; S. E. Slope.

*Myrmica scabrinodis* var. Beaver Creek; The Hook; West Ridge.

*Myrmica brevinodis* var. *canadensis.* Bog B; Inlet Brook; Beaver Creek; West Ridge.

*Leptothorax curvispinosus.* Beaver Creek.

*L. longispinosus.* August 18.

*Tapinoma sessile.* Grass Bog 3; Bog B; S. E. Slope; Beaver Creek; The Hook.

*Dolichoderus plagiatus* subsp. *pustulatus* var. *beutenmulleri.* Trillium Grove.

*Lasius (Lasius) niger* var. *americanus.* The Hook; Beaver Creek; Grass Bog 3; S. E. Slope.

*L. (Chthonolasius) umbratus* subsp. *mixtus* var. *aphidicola.* Beaver Creek; Grass Bog 1; The Hook.

*L. (C.) umbratus* subsp. *minutus.* Grass Bog 1.

*Formica fusca.*

*F. fusca* var. *subsericea.* Bog B; Beaver Creek.

*Camponotus herculeanus* subsp. *pennsylvanicus.* The Shack; S. E. Slope.

*C. herculeanus* subs. *pennsylvanicus* var. *noveboracencis.* Beaver Brook and Bog B.

### Vespidae

*Eumenes fraternus.*

*E. globulosus.* July.

*Ancistrocerus capra.* August 7 to 24; Trillium Grove, August 31.

*A. catskillensis.* July.

*A. tigris.* July.

*Symmorphus debilis.* Inlet Brook.

*Odynerus foraminatus.*

*Polistes pallipes.* Mud Pond.

*Vespa (Vespula) communis.*

*V. (V.) consobrina.* The Shack.

*V. (Dolichovespula) diabolica.* Inlet Brook; The Shack; Grass Bog 2.

*V. (D.) maculata.* Beaver Creek.

### Dryinidae

*Chelogynus viveriensis.* July 26, 1925. (The type.)

### Sphecidae

*Trypoxylon bidentatum.* Bog B, August 7.
*T. frigidum.* August 20; Hemlock Ridge, August 31.
*Sphex sp.* Beaver Creek, September 1.
*Sceliphron coementarium.* The Shack, September 5.
*Stigmus americanus.* S. E. Slope, September 16.
*S. fraternus.* Grass Bog 3, September 16.
*Pemphredon (Diphlebus) tenax.* Beaver Creek, September 20.
*Alysson guignardi.* July.
*Hoplisus (Pseudoplisus) phaleratus.* July 18.
*H. (P.) simillimus.* Beaver Creek. August 1, 1925.
*Aphilanthops frigidus.* Trillium Grove, August 20; The Shack, August 26.
*Cerceris clypeata.* The Hook, August 21.
*C. sp.* Beaver Creek, September 1.
*Solenius (Solenius) parvulus, (Crabro).* July 18.
*S. (S.) obscurus.* May 30 to June 30.
*S. (S.) sayi, (sexmaculatus).* July 18; Beaver Creek, August 30; Hemlock Ridge, June 23.
*S. (S.) trifasciatus.* July 18.
*S. (S.) stirpicola.* July 18.
*S. (S.) singularis, (maculatus?).* July 9 to August 30.
*S. (Crossocerus) nigricornis.* May.
*S. (C.) ater.* Trillium Grove, August 19; Sphaerium Brook; August 31.
*Oxybelus quadrinotatus.* July 18.

### Hylaeidae

*Hylaeus verticalis, (Prosopis).* August 20; Trillium Grove, August 31.
*H. ziziae.* Bog B, August 7; Beaver Creek, August 1.

### Andrenidae

*Andrena arabis.* April.
*A. carlini.* April 17 to May 30; Bog B, June 18.
*A. cressoni.* April; Bog B, June 18.
*A. flavoclypeata.* April, on wild cherry.
*A. hippotes.* April.
*A. hirticincta.* Grass Bogs 1 and 3, August 23.
*A. imitatrix* var. *claytoniae.* April, on wild cherry.
*A. imitatrix* var. *texana.* April, on wild cherry.

*A. mariae* var. *concolor*. April.

*A. nasoni*. April, wild cherry.

*A. sigmundi*. April.

*A. vicina*. April, on wild cherry.

*A. wilkella*.

*Halictus (Agapostemon) radiatus*. Grass Bog 1, August 22.

*H. (A.) virescens*. Hemlock Ridge, September 24.

*H. (Chloralictus) hortensis*. The Hook, August 1; Mud Pond, September 24.

*H. (Halictus) ligatus*. July 18; Grass Bog 1, August 23.

*H. (Oxystoglossa) confusus*. August 19; The Hook, August 31.

*H. (O.) purus*. Beaver Creek, September 16.

*H. (Seladonia) provancheri*. Argus Brook, September 19; Beaver Creek, September 16; Hemlock Ridge, August 24.

*Macropis morsei*. July.

*M. patellata*. July 19.

*Nomada (Gnathias) bella*. May.

*N. (G.) cuneata quadrisignata*. April 17; Bog B, June 18.

*N. (N.) pygmaea*. May.

*Sphecodes arvensis*. July 18.

*Clisodon terminalis*. July 18; Hemlock Ridge, August 31.

*Ceratina dupla*. Beaver Creek, September 16 to 20.

### Megachilidae

*Megachile (Anthemois) decipiens*. Grass Bog 2, August 31.

*M. (Megachile) sp.* (near *exilis*). Beaver Creek, July 25.

*M. (Xanthosarus) latimana*. July 19.

*M. (Cyphopyga) montivaga*.

*Osmia collinsiae*. May 30.

*O. pumila*. Grass Bog 2, July 15.

### Bombidae

*Bombus (Bombus) fervidus*.

*B. (B.) impatiens*.

*B. (B.) ternarius*.

*B. (B.) terricola*.

*B. (B.) vagans*.

*Psithyrus fernaldae*.

*P. laboriosus*. Taken in a nest of Bombus vagans built in sphagnum.

### Apidae

*Apis mellifica* L. Abundant.

# SPIDERS

By C. R. Crosby and S. C. Bishop

## *Order Araneae*

### *Family Dictynidae*

*Amaurobius bennetti.* May.
*A. borealis.* May, July.
*Dictyna cruciata.* May, June, July.
*D. foliacea.* May, July.
*D. maxima.* May.
*D. sublata.* May.

### *Family Gnaphosidae*

*Drassodes neglectus.* June.
*Haplodrassus hiemalis.* June.

### *Family Theridiidae*

*Ancylorrhanis hirsutum.* July.
*Dipoena nigra.* May, July.
*Robertus palustris.* May.
*R. pumilus.* April, May.
*R. riparius.* April, May, June.
*Theonoe stridula.* April, May, June, July.
*Theridion differens.* May, September.
*T. frondeum.* July.
*T. murarium.* July.
*T. spirale.* July.
*Theridula opulenta.* June, July.

### *Family Linyphiidae*

*Bathyphantes alboventris.* September.
*B. intricata.* April.
*B. nigrinus.* July.
*B. zebra.* April, May.
*B. zygios.* April.
*Ceraticelus atriceps.* April, May.
*C. bulbosus.* May, June.
*C. emertoni.* September.
*C. fissiceps.* April, July.
*C. laetabilis.* September.

*C. laetus.* May.
*C. minutus.* April.
*Ceratinopsis nigriceps.* July.
*Dicymbium pectinatum.* May.
*Diplocephalus erigonoides.* May, September.
*D. latus.* May.
*D. minutus.* April, May, July.
*D. rugosus.* May.
*Hypomma bilobata.* May. In moss on tussocks above sphagnum.
*H. trilobata.* May. In same situation.
*Hypselistes florens.* May, July.
*Linyphia clathrata.* May, July.
*L. communis.* May, June.
*L. lineata.* April.
*L. maculata.* July.
*L. phrygiana.* May.
*L. pusilla.* May.
*Lophomma elongatum.* May.
*Maso frontata.* July.
*Microneta cornupalpis.*
*M. longibulbus.* May.
*M. persoluta.* May, June, July.
*M. quinquedentata.* September.
*Oedothorax contortus.* May.
*O. entomologicus.* May.
*O. index.* April, May.
*O. limatus.* May, July.
*O. oxypaederotipus.* May, July.
*O. probatus.* May, July.
*O. rectangulus.* May.
*Pocadicnemis longituba.* May, June, July.
*Prosopotheca communis.* May.
*P. directa.* April, May.
*P. spiralis.* May.
*Tapinocyba distincta.* July.

*Family Argiopidae*

*Araneus cucurbitinus.* May.
*A. marmoreus.* August, September.
*A. stellatus.* July.
*A. trifolium.* September.

*Eugnatha straminea.* May.
*Mangora placida.* May, June. Abundant on heath bogs.
*Neoscona arabesca.* July, August.
*Pachygnatha brevis.* May.
*Tetragnatha elongata.* June.
*T. extensa.* May, June, July.

### *Family Thomisidae*

*Misumena vatia.* May.
*Misumenoides aleatorius.* May.
*Oxyptila conspurcata.* May.
*Thanatus coloradensis.* July.
*Tibellus oblongus.* May.
*Tmarus angulatus.* May.
*Xysticus elegans.* May.
*X. formosus.* May.
*X. graminis.* May.

### *Family Clubionidae*

*Agroeca pratensis.* May.
*Clubiona abboti.* May.
*C. riparia.* May.
*Phrurolithus palustris.* May, June.

### *Family Agelenidae*

*Circurina arcuata.* April, May.
*C. brevis.* April, May.
*C. pallida.* May.
*Coelotes calcaratus.* April, May.
*C. fidelis.* May, October.
*C. hybridus.* April.
*C. montanus.* October.
*Cryphoeca montana.* May.
*Hahnia agilis.* April.
*H. brunnea.* May.

### *Family Pisauridae*

*Dolomedes striatus.* September.
*D. tenebrosus.* May, June.
*D. triton sexpunctatus.* May, July.
*Pisaurina mira.* May.

*Family Lycosidae*

*Lycosa frondicola.* May.
*L. gulosa.* May.
*L. helluo.* April, May, July.
*L. pratensis.* May.
*Pardosa emertoni.* April.
*P. moesta.* June, July.
*P. xerampelina.* May.
*Pirata insularis.* May.
*P. minutus.* June.
*Schizocosa crassipes.* April.
*S. saltatrix.* May.
*Trabaea aurantiaca.* May, June, July.

*Family Salticidae*

*Icius similis.* May, June.
*Metaphidippus capitatus.* May.

# PROTOZOA

By L. A. Hausman

On December 13, 1918, samples of water from various portions of the McLean bogs were taken, at the places indicated by the encircled figures on the accompanying map, with the view of determining the general distribution of the various species of protozoa over the area.

In each case samples were taken from the side of the stream or pond; from the bottom (including some of the bottom deposit); from the surface (so as to include any surface scum that might be present); and from the open water midway, the surface and the bottom. In this way it was hoped that all of the typical protozoan inhabitants of the various water areas investigated might be represented in the samples. Three samples of this composite sort were taken from each locality.

*Station No. 1.* The gravelly bottom of the stream at this point supported a surprisingly rich growth of diatoms, among which a single species each of Nitzchia and Synedra predominated. Other genera present also in large numbers were: Navicula (represented by at least four species), Pinnularia, Diatoma, Asterionella and Gomphonema. Several small clusters of young Oscillatoria strands were noted. Sphaerium Brook in the following list means this station.

*Station No. 2.* None of the higher aquatics were present in the stream where these samples were taken. The bottom was an even, deep deposit of black muck, covered by a vigorous growth of diatoms, chiefly Navicula (three or four species), Nitzchia, Synedra and Diatoma. Water-bears were fairly common among the bottom. In the following list this station is designated as Mud Pond outlet.

*Station No. 3.* These samples were taken near the bank of the pond, in about four inches of water, and among living and dead sphagnum and decaying sedges. Rotatoria of the genera Rotifer and Diglena were fairly common. Among the diatoms, Navicula predominated with three or four species, and Synedra were also fairly abundant.

*Stations Nos. 4 and 5* in Bogs A and B were similar in character and in fauna. They were in the open bog in sphagnum, heavy with water.

*Station No. 6* near the head of Argus Brook was similar to the two preceding with, however, a lesser number of shelled Rhizopods.

*Station No. 7.* The samples here were taken from the clear waters of the spring rill itself, and also from numerous small embayments along its course, which were filled with a sturdy growth of bright green Spirogyra. A large pink species of Ostracod was very abundant among the Spirogyra.

In general it may be said concerning the Protogoa of the reservation that in the clear, colder waters occur mainly the minute, rapidly-swimming, flagellate forms. In the open waters richer in organic content (and probably, also because

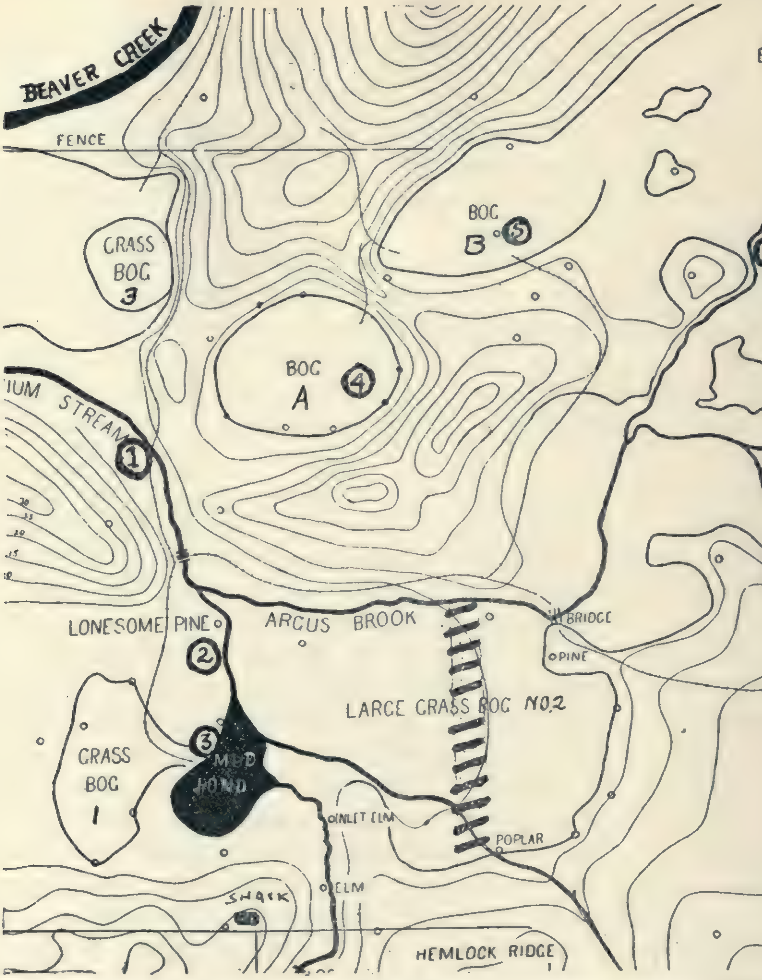



FIG. 15. MAP SHOWING LOCALITIES WHERE PROTOZOANS WERE TAKEN. THE CROSS-LINED STRIP THROUGH GRASS BOG NO. 2 IS THE ONE DISCUSSED ON PAGE 22, ANTE.

of the presence of decaying vegetable tissue, in bacteria) are to be found the more leisurely swimming ciliates; while in the water held in the interlacing sphagnum occur the Rhizopods, which find locomotion easiest in such an environment. The list with localities is as follows:

*Amoeba guttula,* common, Mud P. outlet.
*Arcella doscoides,* few, S. Br.; common, Mud P. outlet.
*Arcella vulgaris,* few, S. Br.; few, Mud P. and Bogs A and B.

*Aspidisca costata,* common, Mud P. outlet and in S. Br. and A. Br.
*Astasia contorta,* common, Mud P.
*Bodo sp?,* common, Mud P.
*Chaenis sp?,* few, Mud P.
*Chilodon cucullus,* common, S. Br.; less common at outlet of Mud P.
*Chilomonas sp?,* few, A. Br.
*Coleps hirtus,* very common, S. Br. and A. Br.; less common Mud P.
*Coleps uncinatus,* few, S. Br.
*Colpidium sp?,* few, Mud P.
*Cyphoderia ampulla,* common, Bog A.
*Cryptomonas ovata,* common, Mud P. outlet, A. Br., Bogs A and B.
*Difflugia globulosa,* few, S. Br. and A. Br.; common, Bogs A and B.
*Difflugia lobostoma,* common, Bogs A and B; few A. Br.
*Enchelys sp?,* common, Bog A.
*Eluglena viridis,* common, Mud P.
*Frontinia sp?,* few, Mud P. and S. Br.
*Heteromita ovata,* common, Mud P. and S. Br.
*Holophrya sp?,* few, S. Br.; common, Mud P. and A. Br.
*Hyalosphaenia elegans,* very common, Bogs A and B.
*Lembadion sp?,* few, Mud P.
*Lionotopsis anser,* few, S. Br.
*Lionotis pleurosigma,* few, Mud P.
*Lionotis fasciola,* few, S. Br.
*Monas sp?,* abundant, Mud P.; common, A. Br. and Eastern Spring; few, Bog A.
*Nostolenus orbiculacis,* abundant, Mud P.
*Oxytrichia pellionella,* abundant, Mud P. outlet; few, S. Br. and Mud P.
*Paramoecium bursaria,* few, Mud P.
*Phacus longicaudus,* common, Mud P. outlet and A. Br.
*Phacus triqueter,* common, Mud P.
*Phrysomonas sp?,* common, Mud P. outlet.
*Quadrulella symmetrica,* common, Bogs A and B.
*Stentor caeruleus,* few, Mud P.
*Spirostomum teres,* few, Mud P.
*Stylonychia notophora,* few, S. Br.
*Urocentron turba,* few, Mud P.
*Vorticella sp?,* few, Mud P.

## INSECT GALLS

Collected September 17 to 24, 1924 By Myron Gordon

| *Plant host* | *Gall maker* | *Page in Felt* * | *Locality* |
|---|---|---|---|
| Salix | *Phytophaga rigidae* | 29 | Mud P. |
| | *Eriophyes sp?* | 30 | Bog 1 |
| | *Rhabdophaga strobiloides* | 30 | B. Cr. |
| | *Pontania pomum* | 34 | I. Br. |
| | *Phytophaga tumidosae* | 36 | B. Cr. |
| | *Rhabdophaga salicis* | 36 | B. Cr. |
| | *Rhabdophaga nodula* | 36 | I. Br. |
| Populus | *Eriophyes sp?* | 38 | S. Br. |
| Carya | *Cecidomyia sp?* | 42 | B. Cr. |
| Fagus | *Eriophyes sp?* | 51 | Shack |
| Alnus | *Eriophyes sp?* | 51 | Bog 1 |
| | *Dasyneura serrulatae* | 51 | S. Br. |
| *Ulmus americana* | *Eriophyes sp?* | 120 | Bog 2 |
| Hamamelis | *Hornaphis hamamelidis* | 132 | Bog 1 |
| *Spireae latifolia* | *Rhabdophaga salicifolia* | 133 | B. Cr. |
| Aronia | *Eriophyes sp?* | 134 | Bog A |
| Crataegus | *Hormomyia crataegifolia* | 136 | B. Cr. |
| | *Lobopteromyia venae* | 137 | A. Br. |
| | *Eriophyes sp?* | 137 | B. Cr. |
| *Prunus serotina* | *Eriophyes sp?* | 148 | A. Br. |
| *Prunus virginiana* | *Eriophyes sp?* | 149 | Bog 2 |
| Rhus | *Eriophyes sp?* | 159 | B. Cr. |
| *Acer rubrum* | *Phylocoptes quadripes* | 160 | Bog 1 |
| | *Phylocoptes aceris-crumena* | 160 | Bog 1 |
| | *Cecidomyia ocellaris* | 160 | Hook |
| Impatiens | *Cecidomyia impatientis* | 165 | A. Br. |
| *Tilia americana* | *Eriophyes abnormis* | 170 | Bog 2 |
| Cornus | *Lasioptera corni* | 175 | Mud P. |
| Vaccinium | *Solenozopheria vaccinii* | 176 | B. Cr. |
| Viburnum | *Cystriphora viburnnifolia* | 187 | A. Br. |
| Solidago | *Rhopalomyia clarkei* | 193 | Mud P. |
| | *Asteromyia aquarrosae* | 193 | Mud P. |
| | *Asteromyia carbonifera* | 193 | S. Br. |
| | *Asteromyia rosea* | 193 | A. Br. |
| | *Eriophyes sp?* | 193 | Mud P. |
| | *Rhopolomyia raccomicola* | 193 | Mud P. |
| | *Asphondylia monacha* | 193 | Mud P. |
| Aster | *Neolasioptera albitarsis* | 201 | A. Br. |
| Erigeron | *Phopalomyia erigerontis* | 202 | S. Br. |

* Felt, E. P. A Key to American Insect Galls. Bull. 200, N. Y. State Museum, 1917. All the species were determined by comparison with the figures and descriptions in this bulletin.

# STUDIES ON TRICHOPTERA

By C. K. Sibley

The Lloyd-Cornell Reservation possesses a remarkably rich caddisfly fauna. I spent the greater part of the season of 1924 there, largely in gathering materials for this paper. I endeavored to collect as many specimens as possible, particularly of the large and difficult family of Limnophilidae, to rear as many species as possible, whether previously reared or not; and to obtain pupae with a view to preparing an introduction to the study of the pupae of American Trichoptera.

The classification of the order here used is that which has been adopted by Comstock in his *Introduction to Entomology*. In his system thirteen families are recognized. It has long been realized that these thirteen families are based on very trivial characters. With a fuller knowledge of the larvae, it has become clear that these groups are not of equal rank. However, thirteen groups still exist and bear their old names, whether they are families, sub-families or tribes; and less confusion will result if I retain the arrangement generally accepted in this country.

Eighty species of Trichoptera were collected in the reservation during 1923 and 1924. Of these, seventeen species have previously been recorded by J. T. Lloyd in his paper on the *Biology of North American Caddis-fly Larvae*.* Twenty-six of the species here recorded have been reared by him and have been described either in the paper just cited or elsewhere. Five species have been reared by other workers. Many of these species were reared again by me and data were obtained to supplement previous accounts. In addition, seven species were reared for the first time and are here described and figured.

Five of the eighty species were represented by insufficient material to permit certain identification. Three species have been described by Dr. Betten, but are still in manuscript. I have been unable to tie up five species with any previous descriptions, and so have described them elsewhere (26) as new.

J. T. Lloyds' collecting had apparently been concentrated on Sphaerium and Argus Brooks for there were few species there which he had not reported. New records were more easily obtained in Mud Pond and in Inlet Brook.

By rearing cages and the tent trap the habitats of the larvae of forty-nine species were determined. Of these three were outside the preserve, one being found only in upper Beaver Creek and two Hydroptilidae only in Gyrinophilus Springs. Twenty-five species were found in Sphaerium Brook; twenty in Inlet Brook; ten in Argus Brook, and seven in Mud Pond.

I desire to express my thanks to Dr. J. G. Needham for suggestions and advice given during the progress of this work; to Dr. C. Betten for suggestions as to interesting problems in the Trichoptera, and for allowing access to the manuscript of his monograph of eastern Trichoptera; also to Mr. D. J. Leffingwell and Mr. M. Gordon for assistance in collecting material.

* Lloyd Library, Bull. 21. Entomol. Series No. 1, 1921.

## ADULT TRICHOPTERA OF THE LLOYD-CORNELL RESERVATION

### Key to Families

1—Size generally 5 mm. or less (6 to 7 mm. in Agraylea); antennae shorter than the body; body and wings generally densely clothed with thickened hairs .............................. *Hydroptilidae*, p. 184

—Size generally larger than 7 mm., if smaller, then wings are not clothed with thickened hairs and antennae are at least as long as the body.... 2

2—Maxillary palpi with less than five segments.......................... 3

—Maxillary palpi with five segments.................................. 5

3—Maxillary palpi four segmented, males............... *Phryganeidae*, p. 185

—Maxillary palpi three segmented..................................... 4

4—Front tibiae with not more than one spur; middle tibiae with no more than three, males ........................... *Limnophilidae*, p. 187

—Spur formula, 2-4-4, males...................... *Sericostomatidae*, p. 186

5—Ocelli present ................................................ 6

—Ocelli lacking ................................................ 9

6—Last segment of maxillary palpi longer than the fourth segment, curved ...................................... *Philopotannidae*, p. 184

—Last segment of maxillary palpi not longer than the fourth segment, straight ............................................... 7

7—Front tibiae with not more than one spur; middle tibiae with not more than three, females ......................... *Limnophilidae*, p. 187

—Front tibiae with two or three spurs; middle tibiae with four.......... 8

8—First two segments of maxillary palpi of about equal length, short and rounded ............................. *Rhyacophilidae*, p. 183

—Second segment of maxillary palpi distinctly longer than the first ........................................ *Phryganeidae*, p. 185

9—Last segment of maxillary palpi secondarily segmented, flexible, much longer than any other segment.................................. 10

—Last segment of maxillary palpi without secondary segmentation, generally not flexible and not longer than any other segment........... 12

10—Front tibiae with three spurs..................... *Polycentropidae*, p. 184

—Front tibiae with two spurs........................................ 11

11—Cell $R_2$ present at least in fore wings............. *Hydropsychidae*, p. 185

—Cell $R_2$ lacking in fore and hind wings............... *Psychomyidae*, p. 185

12—Median cell (first $M_2$) present, closed..............................
............*Calamoceratidae* (sole species *Ganonema americanum*)

—Median cell lacking............................................. 13

13—Discoidal cell (first $R_3$) in fore wing lacking.......................
.....................*Molannidae* (sole species *Molanna blenda*)

—Discoidal cell in fore wing present, closed.......................... 14

14—Lower branch of radial sector unforked (cell $R_4$ lacking); antennae generally twice as long as fore wings; palpi very long and densely paired * ........................................*Leptoceridae,* p. 186

—Both of radial sector forked in fore wing (cell $R_4$ present); antennae and palpi generally otherwise........................................ 15

15—Antennae one and a half times length of fore wings; palpi coarsely hairy; wings brownish gray with dark brown stripes along the veins.... ..................*Odontoceridae* (sole species *Psilotreta frontalis*)

—Antennae but little longer than the wings; palpi finely haired; wings not with above pattern, females only..........*Sericostomatidae,* p. 186

### Key to Species of Rhyacophilidae

1—Spurs 3-4-4; discoidal cell open in both wings...................... ......................*Rhyacophilinae* (sole genus *Rhyacophila*) 2

—Spurs 2-4-4; discoidal cell closed in..................*Glossosomatinae* 3

2—Length 8 mm.; wings shining brown, with a few golden spots.*R. glaberrima*

—Length 10 mm.; wings hairy brown, and spotted with white especially along outer margin.................................*R. gordoni*

3—Length 9 mm.; inner apical spur of male hind tibia modified into a thick curved claw...........................*Mystrophora americana*

—Length not over 4.5 mm.; inner apical spur of male hind tibia straight, normal; Sc of hind wing very short...........*Agapetus minutus*

### Key to Species of Hydroptilidae

1—Ocelli present ..........................................

a. Wings broader, subobtuse, cell $R_2$ of fore wing more than twice as long as its pedical, wings brown, spotted with yellow.......... ................................*Agraylea multipunctata*

aa. Wings narrower, more acute, media of the fore wing arched into radial sector, antennae slender.............*Polytrichia confusa*

aaa. Wings very narrow, strongly acuminate; venation much reduced and obscure; found at Gyrinophilus Springs.......*Oxethira dualis*

2—Ocelli absent; spurs 0-2-4; head with elevated lobes posteriorly.*Hydroptila*

I am unable to give a complete key to the species of Hydroptila found within the preserve. Most of them can be identified only by the male genitalia and even then not with great certainty. For figures of genitalia see Morton (l. c.).

*Hydroptila albicornis* has the antennae whitish to yellowish while the other species have brown to black antennae.

### Key to Genera of Philopotamidae

1—Spurs 2-4-4. Anal veins of hind wings not fused to form a closed cell. Color brown ....................................*Philopotamus*

*Females of one member of the Sericostomatidae, *Helicopsyche borealis,* will seem to run out with the Leptoceridae since R5 appears to arise as a branch of media, thus making the lower branch of radial sector appear forked.

—Spurs 1-4-4. Anal veins of hind wings fused to form a closed cell; color very dark brown to black or with white spots on body and with ground color of wings white........................*Chimarrha*

One local species, *C. aterrima.*

### Key to Species of Polycentropidae

1—Media of hind wing three branched.................................. 2

—Media of hind wing two branched.................................. 3

2—Media and radial sector fused near base of radial sector; length 8 mm. ..................................*Phylocentropus placidus*

—Media and radial sector converging but not fusing..*Phylocentropus lucidus*

3—Cell $R_2$ lacking in both wings...................*Nyctiophylax vestitus*

—Cell $R_2$ lacking in hind wing only................*Holocentropus flavas*

—Cell $R_2$ present in both wings.................................. 4

4—Discal cell present in hind wing; middle tibia of females not greatly dilated ..................................*Plectronemia*

—Discal cell lacking in hind wing........................*Polycentropus*

### Key to Species of Psychomyidae

1—Fore wings with a rounded apex, broad......................*Lype. sp?*

—Fore wings with a pointed apex, narrow.............*Psychomyia flavida*

### Key to Species of Hydropsychinae

1—Anterior margin of fore wing strongly convex; last segment of maxilary palpus longer than the first four segments together............ .................................... *Arctopsyche apicalis*

—Anterior margin of fore wing nearly straight for two-thirds of its length.. 2

2—Subcosta and radius strongly bent toward $R_2$ near margin of the wing; slender lateral filaments on fourth abdominal segment........... ....................................*Diplectrona modesta*

—Subcosta and radius not bent; abdomen without lateral filaments........ 3

3—Cell $R_2$ of hind wing present..........................*Hydropsyche*

—Cell $R_2$ of hind wing lacking......................*Hydropsychodes*

### Key to Species of Phryganeidae

1—Hind wings with a broad sub-apical yellow band, contrasting with the solid dark color of base of wing.......................... 2

—Hind wings pale.................................................. 3

2—Length 21-27 mm.; anterior wings dark brown with numerous yellow spots ....................................*Neuronia pardalis*

—Length 14-18 mm.; anterior wings light brown, very closely spotted with pale....................................*Neuronia stygipes*

3—Hind wings with a fuscous sub-apical band............*Neuronia postica*
—Hind wings without a sub-apical band.............................. 4
4—Length 12 mm.; fore wings shining grayish without hairs, veins brown.. ..................................... *Agrypnia glacialis*
—Length 18-25 mm.; fore wings hairy, gray.......................... 5
5—Length 20-25 mm.; black spines on legs; an interrupted black line through the fore wing...........................*Phryganea interrupta*
—Length 18-21 mm.; yellow spines on legs; no black band in fore wing.... ..................................... *Phryganea vestita*

### Key to Species of Leptoceridae

1—Costal border of fore wing indented near level of the cord; wing incurved beyond this point; color black............*Mystacides sepulchralis*
—Costal border of fore wing not indented; wing straight................ 2
2—Stem of media not separately present in fore wing..........*Triaenodes* 3
—Stem of media present in both wings............................... 4
3—Wings reddish brown, margin with yellow on costal and hind margins.... ............................................ *T. marginata*
—Wings uniform dark brown...............................*T. injusta*
4—Spurs 2-2-2; hind wings broadest at base.................*Leptocerus*
—Anterior tibiae with fewer than two spurs; hind wings broadest near the middle ............................................... 5
5—Media in the fore wing appearing distinctly forked............*Setodes*
—Media in the fore wing not appearing forked, veins very straight and nearly parallel ......................................*Oecetis* 6
6—Fore wings grayish hyaline with five fuscous spots.........*Oecetis avara*
—Fore wings light brown, disk shining purple............*Oecetis incenta*

### Key to Species of Sericostomatidae

1—Costal border of hind wing with a series of curved hooks............ .................................... *Helicopsyche borealis*
—Costal border of hind wing without a series of curved hooks........... 2
2—Spurs 2-3-3; color black....................*Brachycentrus nigrisoma*
—Spurs otherwise, always with four on middle tibiae................. 3
3—Four apical forks present in both pairs of wings (cells $R_2$, $R_4$, $M_1$, $Cu_1$ present) ....................................*Goera calcarata*
—At least one of these forks lacking in hind wing (cell M lacking)...... ................................... *Lepidostomatinae* 4 *
4 *—Costal margin of fore wing reflexed; maxillary palpi densely covered with scale hairs...............................*Olemira costalis*
—Costal margin of fore wing not reflexed.......................... 2

* Males only.

2—A furrow of scale hairs in the hind wing; wings gray with black hairs in both male and female........................*Phanopsyche grisea*
—No furrow of scale hairs in either wing.............................. 3
3—Subcosta of fore wing arched near base and near distal end.......... ........................................*Mormomyia vernalis*
—Subcosta of fore wing nearly straight............................. ..................*Alepomyiodes* (*Lepidostoma*) *wisconsinensis*

KEY TO SPECIES OF LIMNOPHILIDAE

1—Hind wings with nine apical veins before Cu........................ 3
—Hind wings with not more than eight apical veins before Cu. .*Neophylax* 2
2—Fore wings dark brown, yellow in two broad patches along hind margin; length 8-9 mm...................................*N. autumnus*
—Fore wings brown mottled with pale yellow; length 10-11 mm....... ............................................ *N. concinnus*
—Fore wings brown, a narrow yellow band along hind margin; length 8-9 mm.............................................*N. fuscus*
3—Distal part of $R_1$ and $R_2$ of fore wing parallel and strongly bent away from the wing margin; stigma conspicuous, the wing membrane granulate there ...................................*Chilostigma* 4
—Distal part of $R_1$ and $R_2$ of fore wing not so; stigma not conspicuous.... 5
4—Color reddish brown to brown; length 14-17 mm..............*C. difficile*
—Color pale yellow to yellow brown; length 14-17 mm.........*C. pallidum*
5—Post-apical margin of the fore wing somewhat concave................ 6
—Post-apical margin either straight or rounded........................ 7
6—Anterior margin of fore wing nearly straight; post-apical margin distinctly concave; hind wings not deeply excised........*Glyphotaelius*
—Anterior margin of fore wing distinctly convex; post-apical margin only slightly concave; hind wings with a deep incision. .*Arctoecia consocia*
7—Upper fork of media (cell $M_1$) of hind wing usually stalked; outer margin of hind wing with a deep incision; wings pale yellow clouded with brown, veins very dark brown...........*Leptophylax gracilis*
—First fork of media (cell $M_1$) rarely stalked in hind wing............. 8
8—Hind tibiae with fewer than four spurs............................ 9
—Hind tibiae with four spurs; formula (1-3-4)....................... 13
9—Spurs 1-3-3 ................................................. 10
—Spurs 1-2-2 ................................................. 12
10—Anal veins of fore wing abnormal, forming only two basal anal cells, a small one and a much larger one; wings pale yellow with a conspicuous brown stripe along cubitus and across middle of apical cells ...............................*Platycentropus maculipennis*
—Anal veins of fore wing normal, three basal anal cells formed; wing without conspicuous longitudinal stripe.................*Halesus* 11

11—Length 18-22 mm.; posterior dorsal margin of eighth segment produced into a rounded black lobe; wings brown................*H. guttifer*

—Length 15-18 mm.; eighth segment emarginate dorsally with a black lobe on each side; paler than above.......................*H. dan*

12—$R_1$ of fore wing arched near tip; cell $M_2$ of hind wing not as far toward base of wing as the discoidal cell.........*Hesperophylax designatus*

—$R_1$ of fore wing not arched near tip; cell $M_2$ of hind wing nearly as far toward base of wing as discoidal cell...........*Platyphylax lepidus*

13—Sc and $R_1$ of hind wing approximated near margin and there connected by a cross vein; large; length 29 mm.........*Astenophylax argus*

—Sc and $R_1$ of hind wing not connected by a cross vein................. 14

14—Discoidal cell of hind wing three times the length of its pedicel; genae with prominent ventral projections......*Allophylax punctatissimus*

—Discoidal cell of hind wing shorter................................ 15

15—Fore wings long and narrow; cross vein of discoidal cell (M) of hind wing longer than cross vein r-m............................... 18

—Fore wing broader, apex rounded, cross vein of the sector (r) of the hind wing not longer than cross vein r-m.................*Stenophylax*

16—Anterior wings nearly uniformly pale yellow, only lightly clouded with brown, shining, rather elongate.......................*S. gentilis*

—Anterior wings distinctly marked with brown, darker, broad and rounded at apex ................................................... 17

17—Granulations of wing membrane dark brown, conspicuous..*S. scabripennis*

—Granulations of wing membrane of same color as membrane; eighth segment of male concave dorsally....................*S. limbatus*

18—First tarsal segment of male much shorter than the second; anterior spur of male a large curved black spine....*Rheophylax submonilifer*

—First tarsal segment of male longer than the second; anterior spur normal ......................................... *Limnophilus* 19

19—Length 8 mm.; femora black, remainder of legs yellowish; spines black .........................................*L. pulchellus*

—Length 12-15 mm.; legs colored otherwise.......................... 20

20—Wings marked with silvery and fuscous..................*L. ornatus*

—Wings marked only with fuscous................................. 21

21—Length 12-15 mm.; rather paler than the following species; fenestrate spots of fore wings often indistinct; superior appendages of male large, the posterior edge somewhat dentate...........*L. indivisus*

—Length 12-20 mm.; fenestrate spots clearly marked; superior appendages of male very large, very convex externally, yellow, lower margin black and coarsely toothed........................*L. rhombicus*

# FIELD KEY

## For the Identification of Adult Trichoptera Recorded from the Reservation

For greater certainty in determining species, the preceding key is to be preferred; but as a means of quickly locating some of the more striking forms within the preserve, I give below a field key for some of the species found there. I have tried to use mainly characters visible with the naked eye. Adult caddis-flies are obscure insects, generally weak fliers, usually found near bodies of water, with four usually hairy wings which are folded roof-like over the body when at rest, while the antennae project forward.

In the tables below, "very small," refers to insects under 5 mm. in length to tip of wing; "small," to insects 5 to 10 mm.; "medium," 10 to 20 mm. and "large" to insects over 20 mm. long.

I. Small to very small insects, dull colored found mainly along streams, emerging throughout spring and summer. Very small, thickly haired microcaddis flies .............................. *Hydroptilidae*
Dull black, fore wings bent in at tips when at rest, small. . *Mystacides*
Shining black, small, found near riffles; wings straight. . . . *Chimarrha*
Dark brown, small, found by small sluggish streams with mud banks .................................. *Phylocentropus*
Dull brown hairy forms, often spotted with white found along rapid streams .................................. *Hydropsychidae, Polycentropidae, Philopotamidae, Rhyacophilidae*

II. Spring forms (maximum of emergence occurring before the end of June).

1—Hind wings with basal portion dark brown to black and with a broad subapical yellow band.
Large, fore wings speckled with black and yellow. . *Neuronia pardalis*
Medium, fore wings speckled with light brown and dirty yellow. . . . .................................... *Neuronia stygipes*
—Hind wings unicolorous or with dark bands ........................ 2
2—Color mostly black ............................................ 3
—Color not black ............................................... 5
3—Antennae much longer than the wings; size medium ................. 4
—Antennae only a little longer than the wings, size small............ .................................. *Brachycentrus nigrisoma*
4—Abdomen green.............................. *Psilotreta frontalis*
—Abdomen black......................... *Ganonema americanum*

5—Very large, outer margin of fore wing distinctly concave and irregular.. .......................................... *Glyphotaelius hostilis*

—Outer margin either straight or slightly convex. Size medium to very large .................................................. 6

6—Very large, wings with large clear spaces, narrowly bordered with brown; the basal veins are white margined with brown while the apical veins are brown; membrane clear, shining..........*Astenophylax argus*

—Veins not white, margined with brown; membrane hairy.............. 7

7—Fore wings with a longitudinal stripe.............................. 8

—Fore wings various, but without longitudinal stripe.................. 9

8—Stripe white, bordered with dark brown, size medium.............. ................................... *Hesperophylax designatus*

—Stripe black, interrupted, size, very large.........*Phryganea interrupta*

9—Fore wings with two large rhomboid clear areas, wings long, narrow, outer margin straight; emerging also during summer........... ........................*Limnophilus rhombicus* and *L. indivisus*

Size large, dark.................................*L. rhombicus*

Size medium, light....................................*L. indivisus*

—Fore wings without two large clear areas, outer margin distinctly convex. 10

10—Wings gray, size medium.........................*Phryganea vestita*

—Wings yellow, thickly spotted with brown, size large....*Neuronia postica*

III. Summer forms (maximum of emergence between the first of July and the last of September).

1—Antennae twice as long as the fore wings, size not over 12 mm....... ............................................. *Leptoceridae* 2

—Antennae shorter, size usually larger................................ 4

2—Color black, tips of fore wings incurved when folded, apex rounded.... ...................................... *Mystacides sepulchralis*

—Wings narrow, straight at tips........................................ 3

3—Wings reddish brown margined with yellow.......*Triaenodes marginata*

—Wings very dark brown, size small............................*Setodes*

—Wings with purplish reflections..............................*Oecetis*

4—Fore wings with a conspicuous dark brown longitudinal band near hind wings ............................*Platycentropus maculipennis*

—Fore wings without a longitudinal band............................ 5

5—Size small, wings white with black hairs, thus appearing gray, emerging in late August and September................*Phanopsyche grisea*

—Size medium to large................................................. 6

6—Fore wings narrow, straight at apex.....*Rheophylax* and *Limnophilus* 7

—Fore wings broad, margins rounding.................................. 8

8—Wings with two large rhomboidal areas (see key to spring forms)...... ..............................*L. rhombicus* and *L. indivisus*

—Wings without large clear areas, veins very dark brown.............. .................................. *Rheophylax submonilifer*

8—Wing membrane granulate with dark brown....*Stenophylax scabripennis*

—Granulations, if present, not darker than ground color of membrane.... ..........................*Halesus guttifer, Platyphylax lepidus*

(Several large Limnophilidae will run here; the other key should be used to separate them further.)

IV. Autumn forms (emerging from late September through October and November).

1—Small forms, weak fliers, taken near gravelly streams.......*Neophylax*

—Pattern of dorsum when wings are folded is a large yellow band constricted near its middle and bordered by brown....*N. autumnus*

1—Medium forms, often taken at a distance from streams......*Chilostigma*

—Color reddish brown.................................*C. difficile*

—Color yellow to pale yellow brown......................*C. pallidum*

# PUPAE

In the following pages I offer a set of keys in the hope of making possible for the first time the determination of American Trichoptera in the pupal stage. To understand the terms used in the keys I shall give a rather detailed description of the Trichopterous pupae.

*The pupa* of Trichoptera is of the type known as exarate or free; that is, the appendage sheaths are separate and distinct. The head is shaped like that of the adult. The eyes are without facets. They are pale at first but become darker as maturity approaches.

The antennae vary in length according to the species much as they do in the adults. When shorter than the abdomen, they lie along it; if slightly longer, they are bent up around the caudal end of the body, while if distinctly longer, as in the Leptoceridae, they are coiled around the eighth abdominal segment. Segmentation is indicated distinctly or indistinctly.

The mandibles are generally strongly chitinized and large, although in a few genera, as in Neuronia, they are small and poorly developed. In most pupae the sole function of the mandibles is to cut an opening in the pupal shelter when the time for emergence comes. The inner edge of the mandibles is either entire, serrate or toothed. In some forms, for example, Psilotreta, the mandible is used to clean the anterior grating and in these forms a slender process is developed on its distal end.

The labrum is slightly chitinized and bears setae on or near its anterior border; these serve in most species to keep the anterior grating free from silt. The shape of the labrum may be either broader than long or longer than broad. The anterior border may be straight, rounded, emarginate, or produced.

The two pairs of palpi, maxillary and labial which articulate behind of the mandibles, have the same number of segments as in the adults. The labial palpi always have three segments and show but little variation. They are always smaller than the maxillary palpi. The maxillary palpi of all females have five segments. Males have five segmented palpi in the following families: Rhyacophilidae; Hydroptilidae; Philopotamidae; Polycentropidae; Psychomyidae; Hydropsychidae; Lestoceridae; Calamoceratidae; Odontoceridae; Molannidae. In the Limnophilidae and most Sericostomatidae the males have three segmented palpi, while in the Phryganeidae the male palpi are four segmented. These palpi also resemble the adult palpi as to shape and length of the segments.

*Thorax.* The segments of the thorax are similar to those of the adult; that is, the prothorax is a narrow collar while the mesothorax is very large and the matathorax somewhat smaller. The wing cases are not very long, seldom extending beyond the fourth abdominal segment. They may be rounded or pointed at the tips, depending on the shape of adult wing, although in Psilotreta the wing cases are acuminate at the tips while the developing wings are rounded at the tips and do not fill the cases.

The legs closely resemble the legs of the adults both as to size and shape of the segments. I have measured the leg segments of pupae and adult of some of the large Limnophilidae and have found very little variation. The tarsi of the last two pairs of legs bear two rows of swimming hairs which are especially well developed on the middle legs. Often the middle tibiae also bear swimming fringes. The end segments of the tarsi are rounded with the claws only faintly indicated. The tibial spurs, on the other hand, are as distinct as in the adult and of the same number and arrangement. For this reason I have omitted mention of the spurs in most of the descriptions of pupae. However, the number of spurs is a character of great value in classification of Trichoptera. To express the number and arrangement of spurs concisely, a *spur formula* is used which is written spurs 1-3-4 or 2-4-4, etc. The first figure indicates the number of spurs on the fore tibia; the middle figure the number of spurs on the middle tibia, and the last figure the number of spurs on the hind tibia.

*The abdomen.* This is generally soft except for certain chitinous rods along the lateral margins of the dorsum. The segments are marked by distinct constrictions. The dorsum of the first abdominal segment sometimes bears a chitinous process or processes on its caudal margin. These are of considerable taxonomic value. Abdominal segments, three to eight generally bear on the dorsal surface of each a pair of chitinous plates wih minute spines, although the plates may be lacking on segment eight. These plates are located one on each side of the median line, near the anterior margin and the spines point caudad. In addition to these, one or more segments bear plates near their posterior margin. These plates bear a larger number of smaller spines than the first series of plates. The number of these often varies with individuals of a species and even on the two sides of the same individual. For some species they furnish good characters while for others they are useless. I will take this up at greater length under the discussion of Halesus guttifer and Stenophylax (Pyenopsyche) scabripennis.

In the spine formula I use, the abdominal segments are indicated by Roman numerals and the numbers of spines are given in Arabic numerals. To explain this I cite the formula for one of the large Limnophilidae, which is as follows: III, 3-4. IV, 3. V, 4; 12-14. VI, 4. VII, 3-4. This indicates that segments three to seven each have near their anterior margin a pair of plates bearing caudally pointing spines, each plate with the number of spines given in the formula. Variation is shown by two figures separated by a dash, as 3-4. Besides these plates on the anterior margin, the formula shows that segment five also bears a pair of plates near its posterior margin, each of these plates having twelve to fourteen anteriorly directed spines.

The lateral line is a fringe of sericeous hairs, dense or sparse according to the species, which begins on the side of one of the abdominal segments midway between dorsum and venter and continues rearward until it reaches the eighth segment. Here the line may be incomplete and end, but if complete, it loops under the venter of the eighth segment. Its development corresponds to the two well-

known types of Trichopterous larvae. In general the eruciform larvae develop into pupae with lateral lines, while the pupae from campodeiform larva do not develop lateral lines. That is, if the larva has a lateral line the pupa generally has one also.

In general the pupa has gills if the larva had them and these gills are of the same type and often of the same number and arrangement. However, there are some exceptions to this rule. The larva may have gills which are not present at all in the pupa or, on the other hand, the pupa of a gill-less larva may develop gills. The pupa may breathe either by gills or directly through the skin.

In some families (for example, the Hydroptilidae) the last segment of the pupa bears no special appendages, but simply shows some slight suggestion of the genitalia of the adult. The majority of pupae, however, have a pair of appendages on the last abdominal segment. These appendages are very different among the different families and provide excellent taxonomic characters. However, in general, they may all be grouped into two classes: the lobate and the rod-like. The lobate type are broad for their length, lightly chitinized and provided with a number of long, heavy bristles. The rod-like type, on the other hand, are very slender, heavily chitinized and provided with denticles and a few short bristles. The function of the anal appendages is to clean the posterior gratings of the case to permit the free passage of water.

*The pupal shelter.* Other writers have described fully the two great groups of Trichopterous larvae; the campodeiform and the eruciform, also the fact that the eruciform larvae all have portable cases while most of the campodeiform larvae either have no cases at all or have fixed shelters.

As would be expected, there is considerable correlation between the larval shelters and those of the pupae.

The species with eruciform larvae all use the larval case as a shelter for the pupa. If the case is long, as in Triaenodes, the ends are cut off. Then the ends have to be partially closed in order to protect the pupa. However, openings must be left at both ends in order that water may circulate and aerate the gills. This is effected by the use of gratings of many types. The ends may be closed by capping stones leaving small spaces for the circulation of water as in Psilotreta. Or, as Lloyd found in Neophylax, a small section may be cut from one side of the ends of the case and gratings of little rods of silk inserted here between the capping and the case. Or, a network of silk may be spun over the ends of the case and may or may not be protected by capping stones. Or again, the ends may be closed by a disk of silk in which an opening is left for the passage of water. This opening may be circular as in Triaenodes, or a vertical slit as in Molanna. The cases may or may not be fastened to a support.

Among the campodeiform larvae, the Hydroptilidae which have portable cases with the exception of Polytrichia (Ithytrichia) confusa Morton, fasten their cases to a support by disks of silk and seal the ends of the cases preparatory to pupation. Sometimes one edge of the case is against the support as in Hydroptila,

or one of the broad flat sides is against the support as in Agraylea and Oxethira. The pupa is always free in the case.

I found one interesting specimen of Hydroptila delineata which had fastened a number of small stones to its case and to each other in such a manner that they covered the case completely above and made the structure resemble very closely the pupal shelter of one of the Hydropsychidae.

The Glossosomatinae, which have portable cases like the shell of a turtle, cut away the floor of the case and fasten the edges tightly to a stone. The pupa is enclosed in a brown cocoon without perforations and fastened to the case only at its posterior end.

In general, the other campodeiform larvae construct a pupal shelter which may be a little ring of stones between two large stones close together, as in Rhyacophila, or a loose hemispherical shelter as in the Hydropsychidae and Philopotamidae, or an enlargement of the larval tube as in Phylocentropus. In this the pupa lies in a cocoon which may be either gray, yellow, or brown.

In the Rhyacophilidae and Philopotamidae this cocoon is without perforations while in the Hydropsychidae, Polycentropidae and Psychomyidae the cocoon has several perforations in each end.

*Length of the pupal period.* The pupal stage of those species which I have observed lasts about two weeks and this is the observation also of workers with European species. The caddisflies seem to pass the winter without exception now known, either as partly grown larvae or as prepupae. Often a species will be in a case as a prepupa for a space equal to or longer than the duration of the pupal period. Lloyd has reported on the very interesting instance of Neophylax which remains as a prepupa during most of the summer.

In the keys to nymphs which follow, I have borrowed freely from European authors for genera not reared in this country as yet; from Dr. J. T. Lloyd for pupae described by him; also from Dr. Vorhies and Dr. Betten for similar materials.

### A Key to the Families of Trichoptera—Pupae

1—Pupa in a cocoon within a pupal chamber.......................... 2
—Pupa not in a cocoon, but free inside the larval case................ 7
2—Pupa in a thickened swelling of the larval tube; abdomen ending in four membranous lobes with numerous black setae.................. ............................ *Polycentropidae* (*Phylocentropus*)
—Pupa in a cocoon inside a shelter, one side of which is closed by the substratum to which the shelter is attached..................... 3
3—Cocoon resembling a fly puparium, yellow or brown, glossy and without perforations; in a chamber of little stones to which it is fastened only at the posterior end......................*Rhyacophilidae,* p. 196
—Cocoon grayish, adhering to the shelter along its entire surface......... 4
4—Pupae with tracheal gills...................................... 5

—Pupae without tracheal gills.......................................... 6

5—Mandibles heavy, nearly straight and strongly toothed; gills branched; spurs 2-4-4; anal appendages rod-like (sometimes very short and thick), emarginate at tips.......................*Hydropsychidae*

—Mandibles slender, curved, with margins entire; gills single, unbranched; spurs 3-4-4; anal appendages lobate and with heavy bristles........................................... *Polycentropidae,* p. 197

6—Mandibles heavy on basal half, then prolonged into a long and very slender appendage; cocoon grayish with perforations at each end, placed in an ellipsoid chamber of sand grains........*Psychomyidae*

—Mandible of nearly even width throughout, heavily toothed near tip of inner margin; cocoon imperforate, in a shelter of little stones.......................................... *Philopotamidae*

7—Size small, rarely more than 5 mm. long; cases flat, usually entirely of silk, in some genera with the addition of sand grains or algal filaments; cases sealed tightly at each end, usually fastened to a support by disks of silk..............................*Hydroptilidae,* p. 197

—Size larger, rarely less than 7 mm. long; cases of a different character, always with openings at the ends.......................... 8

8—Antennae much longer than the body, coiled around the caudal end of the abdomen ................................................ 9

—Antennae at most but little longer than the body..................... 10

9—Mandibles broad on basal half, then produced into a long slender process; lateral line incomplete running from sixth to eighth segments; gills in bunches.................(*Psilotreta frontalis*) *Odontoceridae*

—Mandibles without long slender process; lateral line running from the third segment to the eighth; gills absent or present, if present, either single or in bunches..........................*Leptoceridae,* p. 197

10—Mandibles with a large tooth on the inner margin; dorsal spines on each of segments 3-7 in a single row on a pair of long transverse plates..................(*Ganonema americana*) *Calamoceratidae*

—Mandibles without a large internal tooth; dorsal spines otherwise....... 11

11—Ends of case closed by a disk of silk having a vertical slit; case of sand, flattened dorsoventrally and with lateral flanges; gills in bunches.......................................... (*Molanna*) *Molannidae*

—Ends of case closed by gratings of various types, not by a disk of silk; cases of different form than above............................ 12

12—Anal appendages lobate............................................ 13

—Anal appendages rod-like............................................. 16

13—Case of coarse sand grains, resembling the shell of a snail........................(*Sericostomatidae*) *Helicopsyche borealis*

—Case not heliciform.................................................. 14

14—Posterior margin of the first abdominal tergite produced caudad in a distinct median process........................*Phryganeidae,* p. 198

—Posterior margin of the first abdominal tergite produced laterally into two low spinous tubercles.....(*Sericostomatidae*) *Lepidostomatinae* 15

15—Inner margin of mandible entire; lateral line yellow..*Phanopsyche grisea*

—Inner margin of mandible finely toothed; lateral line dark brown...... ................................... *Lepidostoma wisconsinensis*

16—Posterior margin of the first abdominal tergite produced into a broad rounded process which is distinctly emarginate; or, posterior margin nearly straight, with a slight median emargination; never more than one spur on the front tibiae...................*Limnophilidae,* p. 198

—Posterior margin of the first abdominal tergite produced into two small lateral tubercles ........................................ 17

17—Case of stones with ballast stones on the sides; anal appendages setiform, divergent, recurved...(*Sericostomatidae, Goerinae*) *Goera calcarata*

—Case of plant materials, square in cross section; anal appendages setiform, parallel, decurved .......................................... .....(*Sericostomatidae, Brachycentrinae*) *Brachycentrus nigrisoma*

### Key to Certain Genera of Rhyacophilidae—Pupae

1—Mandibles asymmetrical with two teeth on left mandible and three on right; spurs 3-4-4; cocoon shining reddish brown................. ........................*Rhyacophilinae* (sole genus *Rhyacophila*)

—Mandibles symmetrical with one or two teeth on each; spurs 2-4-4; cocoon yellowish to reddish brown.......................*Glossosomatinae* 2

2—Mandibles with one tooth internally; length 6 mm.; with dorsal spines on posterior margin of segments four, five and nine in male, not on ninth in female; antennae extend to seventh segment...*Mystrophora*

—Mandibles with two teeth internally; antennae as long as the body........ 3

3—Length 8 to 11 mm.; spurs of posterior tibiae unequal; dorsal spines as in Mystrophora ...................................*Glossosoma*

—Length 3.5 mm.; spurs of posterior tibiae subequal; dorsal spines only on posterior margin of fourth segment in addition to the usual ones on anterior margin of segments four to seven..............*Agapetus*

### Key to Genera of Hydroptilidae—Pupae

These are most easily distinguished by the form of the case.

1—Case reniform, of silk covered with a layer of fine sand, fastened to the support with one of the edges against it..............*Hydroptila*

—Case usually entirely of silk, sometimes with a few filaments of algae, never with sand grains; fastened to a support with one of the broad faces against the support...................................... 2

2—Case oval, not flattened; with strong, longitudinal keels and grooves; length 3½ to 4½ mm............................*Orthotrichia*
—Case otherwise, flattened, glossy, usually with adhesive discs............ 3
3—Case 7 to 9 mm. long, distinctly broader in the middle..........*Agraylea*
—Case not more than 4 mm. long.................................... 4
4—Case about 4 mm. long; approximately bottle shaped...........*Oxethira*
—Case oval, smaller............................................. 5
5—Case oval, with a cylindric addition at the posterior end and an adhesive disc at the anterior end................................*Ithytrichia*
—Case oval, without a floor and without the cylindric addition....*Polytrichia*

### Key to Certain Genera of Polycentropidae—Pupae

1—Each of the lobate anal appendages having near its base on the outer side a smaller setiferous lobe; pupa in a swelling of the larval tube..... ........................................... *Phylocentropus*
—Lobate anal appendages without an external lobe..................... 2
2—Anal appendages with the apex squarely cut off and with the inner apical angle produced into a blunt point...................*Neureclipsis*
—Anal appendages with the apex rounded and without an internal tooth.... 3
3—Segments two and four of the anterior tarsi densely hairy...*Polycentropus*
—Anterior tarsi not hairy...........................*Plechtrocuenmia*

### Key to Certain Genera of Leptoceridae

1—Case of vegetable material spirally wound; gills single, simple; mandible slightly produced at middle of the inner margin and having there six or seven distinct teeth..........................*Triaenodes*
—Case not of material laid on spirally; gills various, mostly lacking; mandibles without a group of teeth at middle of inner margin...... 2
2—Gills present ................................................ 3
—Gills absent ................................................. 4
3—Inner edge of mandible toothed from tip to middle, the teeth becoming larger near the middle and the mandible sharply indented there; gills single ..........................................*Oecetis*
—Inner edge of mandibles only finely serrate, never toothed; mandibles variously shaped but never indented; gills single or in bunches.... ............................................ *Leptocerus*
4—Case of coarse sand and small pebbles with ballast sticks on the sides.... .................................... *Mystacides sepulchralis*
—Case mainly of silk, sometimes partly covered with sand................ 5
5—Anal appendages long and slender of rather uniform width; mandibles nearly straight, tapering regularly to a point; case of silk partly covered by sand grains......................*Leptocella exquisita*

—Anal appendages very broad on basal half, then tapering rapidly to a point; mandibles straight and of uniform width for two-thirds their length, then suddenly reduced in width by half and curving to a slender point; case entirely of silk ............... *Setodes grandis*

### KEY TO CERTAIN GENERA OF PHRYGANEIDAE—PUPAE

1—Mandibles small, rhomboidal, lightly chitinized (Fig. 94) ....... *Neuronia*
—Mandibles larger, saber-shaped, heavily chitinized (Fig. 37) ... *Phryganea*

These characters are the same as those used by Lloyd to separate the pupae of these two genera. However, it must be remembered that the pupae of some European species of Neuronia have large saber-shaped mandibles. So that when the immature stages of more of our species are known, it is quite probable that this key will become inadequate. There seems to be no clear division between the two genera.

### KEY TO CERTAIN GENERA OF LIMNOPHILIDAE—PUPAE

1—Gills branched ........................................ 2
—Gills simple, in bunches of two or three ........................ 3
—Gills simple, single ........................................ 6
2—Spurs 1-3-4 ........................................ *Allophylax*
—Spurs 1-2-2 ........................................ *Hesperophylax*
3—Size large, length about 22 mm. ........................ *Glyphotaelius*
—Size smaller, length about 16 mm. ........................ 4
4—Notch in posterior margin of first abdominal tergite broad, truncate at tip; case an arched cylinder of small stones and bits of bark with a few larger bark and wood fragments laid on lengthwise ..... *Chilostigma*
—Notch in posterior margin of first abdominal tergite V-shaped; cases of plant fragments laid on transversely ........................ 5
5—Case of even diameter throughout, materials composing trimmed evenly .. ........................................ *Platycentropus*
—Case ragged, materials composing it not trimmed evenly .............. ........................................ *Limnophilus* (in part)
6—Size large, length about 22 mm., case bulky, made of bark and wood fragments ........................ *Astenophylax argus*
—Size smaller, not longer than 18 mm. ........................ 7
7—Anal appendages setiform, recurved at tip; posterior border of first abdominal tergite nearly straight; size 6-9 mm.; case of small stones with larger ballast stones on the sides ................. *Neophylax*
—Anal appendages stouter, not recurved; posterior border of first abdominal tergite distinctly produced and notched; size generally larger ...... 8
8—Spur formula 1-2-2 ........................................ *Platyphylax*
—Spur formula 1-3-3 ........................................ *Halesus*
—Spur formula 1-3-4 ........................ *Stenophylax, Arctoecia*

# LIFE HISTORIES

## Rhyacophilidae

*Agapetus minutus.* J. T. Lloyd reported larvae of this genus from Michigan Stream above Spencer Lake, but did not rear them. This species occurred in Inlet Brook in small numbers.

I experienced great difficulty in the field in distinguishing cases of Agapetus from cases of partly grown Mystrophora. The Agapetus larvae would be found on the same stone with young Mystrophora in the proportion of one of the former to five or even ten of the latter.

*Description of larva.* Length 4 to 4.3 mm. Breadth 1 mm. (in region of third and fourth abdominal segments).

Head very dark brown except for a pale ring around eye. Labrum brown; clypens pale, membranous. Antennae arising close to base of mandibles, very small, pale. Frons very broad. Mandibles broad, black, with a curious internal brush of little ribbons.

Thorax with pronotum long, somewhat narrowed in front; color dark brown to black. Mesonotum with a pair of large dark brown plates. The plates have one side parallel to the anterior margin of the segment. Metanotum with a pair of small round dark brown plates located near the anterior margin. Prosternum chitinized, dark brown. Meso and Meta sterna membranous, white. Legs with coxae dark brown; other segments pale yellow.

Abdomen white, tinged with pink above. Sternum of first abdominal segment with four setae; sixth and seventh without setae; sterna of all other abdominal segments with two setae. On the sternum of the second abdominal segment are two low swellings. Each of these is covered with very minute spines, directed forward. The chitinous plate on the ninth abdominal tergite is large, dark brown to black and bears six setae on its posterior margin. Prolegs are short and thick, dark brown in color and have four long setae near their distal end. The drag hooks are small and yellow in color. No gills are present except retractile anal gills.

*Description of case.* The case is a miniature Mystrophora case, that is, it resembles the shell of a turtle with an arched carapace above, and a flat, broad plastron below. As is true of Mystrophora, the pupal case of this genus has no floor or "plastron."

*Description of pupa.* The cocoon is of clear silk without openings and is light brown in color. The pupa is readily visible within.

Length of pupa, 3.5 mm. Breadth, 1 mm.

As is true of other species, the pupa is very pale at first but becomes pigmented more deeply as development proceeds.

Mandibles large in comparison to size of head, broad at base, curved and tapering regularly to tip, with two prominent teeth at middle of inner margin.

Antennae about as long as body. Tarsi of hind legs with swimming fringes. Dorsal spines as follows: IV, 6-7; 21-29. V, 12-13. VI, 10-14. VII, 9. Gills lacking. The caudal end of the abdomen is not provided with anal appendages, and is a white membranous cylinder bilobed at the end. The pupal stage lasts about two weeks.

*Mystrophora Americana*

Larvae and pupae of this species were taken on June 2 in Sphaerium Brook riffles, where a pair of adults *in copulo* were taken on June 1. Fully grown larvae were still found on July 1 and 2. Young larvae were large enough to be conspicuous on July 28, and were common in September when they were easily confused with Agapetus. Larvae were found also in Inlet Brook. Adults were caught on June 1 and 12; and in the tent trap on August 14, 17 and 18. A dark female specimen was taken at the Shack on August 28.

This species is the one reared by Lloyd and described under the genus Glossosoma. It was found by Dr. Betten that the male possesses the characters of Mystrophora Klapalek; so that name is here used.

*Description of pupa.* Cocoon, dark brown silk.

Length 6 mm.

Antennae extend to anterior margin of 7th segment. Mandibles large, curved and tapering with a large tooth at middle of the inner edge. Labrum broader than long, with marginal setae and also a setae near each antero-lateral angle. Dorsal spines as follows: III, 14-15. IV, 17-18; 41-45. V, 16; 36-42. VI, 15-16. VII, 17-21. VIII, 15. IX, 32. No spines on segment eight in the female. End of abdomen with two tufts of long black setae arising dorsally near posterior margin of segment. This terminal segment is folded under the abdomen and the setae point cephalad when the pupa lies in the cocoon.

## Hydroptilidae

I was able to collect seven species of this interesting family of minute forms and to rear three of these.

*Agraylea multipunctata*

This common European species has been reared by Siltala and described and figured with such detail that it is quite useless to redescribe the stages. The larvae were very common in Mud Pond on the Potamogeton stems where they fed on algae and diatoms. On the ends of the cases were fastened several rows of Spirogyra filaments.

Adults began emerging on June 29, and continued until September 21 without a gap except from June 30 to July 27.

They are afternoon and twilight fliers rather than nocturnal forms. During cloudy afternoons in September they could be seen near the shores of the pond in large numbers, flying close to the water and frequently lighting on the surface.

### *Hydroptila delineata*

Cases of this species were found to be very common on the rocks in the outflow from Grinophilus Springs and from similar springs near by. Adults emerged from August 7 to September 12. Pupae were still in the cages when these were taken up on September 21. Larvae were also present on the same day.

*Description of case.* Length 5 mm. Maximum depth 1.6 to 1.75 mm.

In shape and structure the case is similar to those of other members of the genus. That is, it is more or less reniform but much flattened and with a slit at each end. It is composed of silk covered with a single layer of fine sand grains.

*Description of larva.* Length 4 mm. Maximum depth (fifth abdominal segment) .75 mm. Depth of first abdominal segment .3 mm.

Head black except a yellow eye ring. Labrum yellow; mandibles brown, yellow near tips; a pair of very long setae between the eyes, shorter setae on vertex and frons.

Thorax: the three thoracic tergites are heavily chitinized and black. The prosternum bears three small brown plates. The meso and meta sterna are membranous and white. The precoxal plates and the legs are dark brown to black.

Abdomen entirely membranous and white except for a small chitinous ring on the tergites of each of the first three segments. The abdomen is strongly compressed and has deep constrictions between the third to eighth segments. Gills absent. Chitinous plate on dorsum of nineth segment pale yellow, with several black setae arising from posterior margin. Prolegs yellowish brown, very short; drag hooks stout.

*Description of prepupa.* Length 4.2 mm. Maximum depth 8 mm. Depth of first abdominal segment .66 mm.

The case is sealed tightly at each end. The mature pupa is very dark.

Antennae extend just beyond the caudal margin of the third abdominal segment. Mandibles curved, swollen at base, then tapering regularly to tip. Wings extend to tips of abdomen. Dorsal spines as follows: III, 4; 8. IV, 7; 8. V, 5; 12. VI, 7. VII, 11. Most of these spines are extremely small.

### *Oxethira dualis*

The male genitalia agree with Morton's figure, although the type of this species came from New Mexico.

The beautiful cases of larvae and pupae were common in Gryinophilus Springs particularly in moss and algae. Adults emerged from August 20 to September 9.

*Description of case.* Length 4.5 mm. Greatest breadth 1.2 to 1.25 mm. Minimum breadth .5 mm. Maximum thickness .7 mm.

The point of maximum breadth may either be at the larger end of case as it always is in young larvae, or 2.6 mm. from the larger end. Until time for pupation the cephalic end of the larva is at the smaller end of the case. This is because of the large size of the abdomen.

The case is made only of the silken secretion. As indicated by the above measurements about three-fifths of the case is a flattened tube of nearly uniform breadth but the remainder of the case tapers rapidly, resembling a funnel or the neck of a milk bottle. The small opening has the edges flared out.

*Description of mature larva.* Length of head and thorax .75 mm. Length of abdomen 3.2 mm. Maximum thickness (depth) of abdomen .82 mm. Maximum breadth of abdomen .75 mm. Approximate maximum breadth of thorax .2 mm.

Head pale yellow, posterior margin brown. Tergites of the three thoracic segments completely chitinized, color pale yellow, posterior third brown. Gills absent. Prolegs short. Dorsal shield on nineth abdominal tergite dark brown with long black setae. Abdomen white in alcohol, pale green in life.

*Description of pupal case.* Before sealing the case the larva fastens it to moss or to stones by little bands of silk ending in disks of the same. There may be two of these attachment bands from each side of the broad end of the case or only one from each side. The small end of the case is fastened by from two to four similar bands. Sometimes the case is fastened only at the small end.

The larva seals the small end of its case with a sheet of the silk secretion leaving no openings at all. Then the walls of the case are thickened nearly to the broad end by spinning another layer of silk. This layer stops about 1 mm. from the broad end of the case. A narrow sheet closes the case along the line where the extra layer ends.

Before pupating the larva always turns so that his head is at the broad end of the case and the pupa always lies in a similar position. The mature larvae are somewhat pinched when they assume this position and crowd the large abdomen into the small end of the case.

The larval dejecta are left in the small end of the case.

*Description of pupa.* The young pupae are a beautiful pale green, but they turn black as they approach maturity. On August 3, all pupae of this species at Gyrinophilus Springs were immature and pale green.

Antennae extending to posterior margin of sixth segment. Mandibles very similar to those of Hydroptila but with less curvature; swollen at base, then tapering to tips. Dorsal spines: There is a striking difference in the arrangement of dorsal spines. The spine bearing plates near the anterior of segments three to seven are linear and parallel to the long axis of the body. These plates bear five to six relatively large spines while the plates at the posterior margin of segments are small and transverse and bear eight to twelve very small spines. The formula is as follows: III, 5-6; 10. IV, 5-6; 12. V, 6; 8. VI, 5. VII, 5-6.

### Key to Genera of Larvae of Hydroptilidae

I. External gills present, formed by lateral evaginations of abdominal segments three to eight; case in form of an urn. . *Ithytrichia*

II. External gills lacking.

A. Fifth, sixth and seventh abdominal segments greatly swollen; case not portable. . . . . . . . . . . . . . . . . . . . . . . . . . *Polytrichia*

AA. Fifth, sixth and seventh abdominal segments not greatly swollen; case portable.

B. Case always composed of grains of sand, more or less yellow; reniform. Legs short, the posterior about one and a half times as long as the anterior. . . . . . . . . . . . . . . . . *Hydroptila*

BB. Case never of sand, more or less green, generally of silk, sometimes covered with algae.

C. Posterior legs more than twice as long as the anterior; cases flat, dorso-ventrally keeled.

D. Case bottle-shaped; broadest behind. . . . . . . . . . . . . . . . . . *Oxethira*

DD. Case broader in the middle than at either end. . . *Agraylea*

CC. Posterior legs shorter; case never flattened, nor dorso-ventrally keeled . . . . . . . . . . . . . . . . . . . . . . . *Orthotrichia*

### Philopotamidae

#### *Chimarrha aterrima*

The larva of this species were very common in the gravelly part of Sphaerium Brook. Larvae were collected on June 4, 6; July 1, 5; August 19; pupae on June 12; July 2, 28; August 15, and adults on May 31; June 12; July 1, 15, 22; August 11 to 22, August 31. During the period from August 14 to 22, inclusive, two hundred adults emerged in the tent trap covering a space of twelve square feet.

A gray color phase appeared which graded into the normal dark form.

*Description of the gray phase.* Head black, four white warts on the vertex as follows: two large transverse warts at the rear margin of the head and two smaller rounded triangular ones between, but just posterior to the rear ocelli.

Thorax; two rounded white warts on each side of the median line on the pronotum. Tegulae of the front wings white. A round white spot on the mesoscutellum. Wings—both pairs are white covered with a dense black pubescence, which gives them a gray appearance. Legs—femur of mesothoracic leg with a light longitudinal stripe on distal half. Femur of metathoracic leg with a broad irregular band around middle; tibiae pale with black pubescence.

In the typical dark form all these areas become either fuscous or black. Many intermediates were found and this, together with the identical male genitalia makes it certain that the gray form is a color phase only.

### Polycentropidae

#### *Phylocentropus lucidus*

The larval tubes were exceedingly abundant in the upper part of Sphaerium Brook and the lower part of Argus Brook. In many places the bulk of the tubes was equal to or greater than the surrounding mud. Tubes containing mature larvae and young pupae were collected along Argus Brook on June 19. Adults emerged in rearing cages on June 22, 23, 28 and July 1 and 4. Adults were also collected on Sphaerium and Inlet Brooks and at the Shack. Dates range from June 10 to August 22.

Dr. Betten has placed this species in a new genus Acrocentropus because of a character in the wing venation. However, on the basis of larval structures and habits, it seems that this species should remain in the genus Phylocentropus.

The shelter is a branching tube of silk covered with sand and small bits of partly decomposed bark and wood. This is constructed under the silt while one end projects above the surface of the mud to maintain connections with the clear water. The walls are rather thick and firm enough so that the tube retains its shape when removed from the water.

*Description of larva.* Length 15 mm. Breadth 1 mm. In its slenderness this larva resembles the larva of Chironomus.

Head yellow except for a darker area on the frons and a white eye ring. Frons very long, nearly attaining the posterior margin of the head. Labrum pale yellow with a small brown spot at center of caudal margin. Mandibles yellow, margined with brown; broad, variously toothed and with a dense brush of hairs internally. Labrum terminal segment slender, greatly elongated.

Prothorax and head much more slender than remaining segments. Pronotum chitinized, yellow, posterior margin black. Meso and meta notum membranous, white. Legs yellow, coxae, femur and tibia margined with black. All segments short. Precoxal plates black.

Abdomen membranous, white. Posterolateral angles of eighth abdominal segment with short thumb like projections. Prolegs long and slender, two segmented. Draghook yellow; large and strongly curved.

The pupae lies in an enlargement of the larval tube. Its cocoon adheres to the walls of the tube and its ends are perforated to allow the passage of water.

*Description of pupa.* Length 8 mm. to 12 mm.

General color pale. Antennae as long as the body in the male, shorter in female. Mandibles basal third swollen, apical portion slender, curved, but with only slight taper.

Abdomen ending in four lobes covered with numerous black setae. Dorsal spines as follows: III, 9-10. IV, 8-9. V, 8-10; 5. VI, 8-9. VII, 7. VIII, 5-6. No lateral line. There are two gills at the anterior margin of the pleurae of segments two and five inclusive.

## Odontoceridae

### *Psilotreta frontalis*

Larval and pupal cases were very common in the gravelly part of Sphaerium Brook. Adults were taken from June 16 to 23.

*Description of pupa.* Length 11 mm.

Antennae longer than body, making one and one-third turns around end of abdomen. Labrum broader than long, with setae along lateral margins. Mandibles broad, tapering evenly and terminating in a slender curved process which is bifid at tip.

Wing sheaths are sharply pointed at tips while in the adults the wings are rounded at apex. Pronotum with a large tubercle on each side of the median line. Dorsal spines as follows: III, 1. IV, 1. V, 1; 2. VI, 1. VII, 1. VIII, 1. Gills in tufts as on the larva. Lateral line very short, beginning on caudal margin of sixth segment and continuing to the anterior half of the eighth segment where it is prodeced caudad in a long tuft. Hairs are yellow, sericeous. Anal appendages very long and slender, running parallel with little taper for half their length, then diverging rapidly and tapering to a slender point.

## Leptoceridae

### *Triaenodes marginata*

The larvae were common in the Chara and Potamogen beds of Mud Pond. Adults emerged on July 24. Dates of capture of adults range from July 6 to August 27. Most of the specimens were taken on the pond, but a few were taken at the Shack and one at Inlet Brook.

*Description of larva.* Length of larval case 23 mm.; 29 mm. Maximum outside diameter 2 mm. Length of larva in the 29 mm. case 14 mm. Length of larva in the 23 mm. case 10 mm. The case is a spirally wound cone of the same type as that of other species of the genus.

Head, ground color light yellow. A narrow longitudinal brown stripe on each side of the frons, following the arms of the epicranial suture but fading out before the two sutures meet. A broader brown stripe starting at the base of the mandible and ending at the posterior margin of head against the epicanial suture. A brown stripe starting some distance back of and slightly above the eye, and extending straight to posterior margin of head. Two rows of round dots starting slightly back of and just below the eye and running parallel to the stripe above the eye. A brown stripe extending from lower inner edge of mandible and extending straight nearly to posterior margin of head. Bases of the antennae narrowly margined with brown emarginate on anterior margin. Gula sub-quadrate.

Pronotum chitinized, very pale yellow. Two transverse light brown spots near anterior margin. Hind angles margined with very dark brown to black.

Meso and Meta thorax white, membranous. Mesonotum with several bristles bearing spots. A black mark at base of coxa.

Abdomen white. Gills very few, single (Fig. 54). Spacing humps flattened, not prominent. No lateral line. Ninth segment with a prominence near posterior margin bearing six long black bristles and four finer bristles.

Food. This species is herbivorous. Stomachs examined contained a coarse filamentous green algae, probably Spirogya; fragments of leaves, probably of a Potamogeton and a few diatons.

Before pupation the larvae cuts off the narrower portion of its case so that the pupal case is always much shorter than that of the larva. The ends of the case are closed with disks of silk having a round hole in the center to allow the circulation of water. The larval dejecta are lost through the hole in the posterior disk. These pupal cases are fastened to leaves and stems of Potamogetons and are quite inconspicuous.

*Description of the pupa.* Length of pupal case 13 mm. Maximum diameter 2.6 mm. Length 19 mm. to tip of anal appendages. Length of append 1⅓ mm.

Head yellow. Mandibles slender, slightly curved, brown, distinctly produced near the middle of the inner margin, having there six to seven strong teeth. Palpi legs and wings white. Antennae white, very long, curled several times around eighth and ninth abdominal segments. Labrum longer than broad, not armed with bristles.

Thorax white.

Abdomen yellow. Gills same as in larva in number and arrangement. Dorsal spines III, 2. IV, 2. V, 2; 8. VI, 2. At anterior margin of tergites of each segment except the first and ninth is a pair of black or brownish spots. These are prolonged to posterior margin of the segment as golden brown lines. On dorsum of ninth abdominal segment a pair of widely separated tubercles each bearing three black bristles. Anal appendages long, slender, straight and of nearly uniform width for two-thirds their length. Then the outer margin curves slightly while the inner margin curves still more in the same direction, making a long curved tooth. No lateral fringe.

## Molannidae

### *Molanna blenda*

This species was previously reported from McLean * by Lloyd, but was not reared. The larvae were very common on the sand and silt bars in Argus Brook and Inlet Brook and in the gravelly portion of Sphaerium Brook. In spite of the inconspicuous nature of the case, larvae could be quite easily detected, mainly because of their movement. However, pupal cases were very difficult to find because they were covered over with sand and silt.

* Lloyd Libr. Bull. 21: 105. 1921.

Adults were taken from the 13th of August to the 16th of September.

*Description of case.* Length 15 mm. Maximum breadth 8 mm. Minimum breadth 3 mm.

This case is of the same form as those of other members of the same genus with thin, flat extensions along the sides and over the head in front, and so need not be described in detail. It is constructed almost entirely of coarse sand, but on the mud bars in Sphaerium and Argus Brooks, bits of bark and pellets of frass were attached here and there on top of the sand grains. These additional materials contribute nothing to the strength of the case, being very loosely fastened by a few threads of silk.

*Description of larva.* Length 12 mm. Width 2-2.3 mm.

Body in life white.

Head pale yellow; a dark brown band following the epicranial suture throughout its length, a pale brown band across middle of frons connecting the arms of the dark band; a pale brown band running dorso-ventrally on side of head midway between eye and hind margin. Gular region brown. In pale specimens the band across frons may be absent as also the band on side of head. Clypeus and labrum light brown. Mandibles golden brown, darker along margins. Antennae pale, slender, arising near base of mandibles. Gula quadrate.

Pronotum, posterior margin black, posterior half dark brown, shading off to pale yellow on antero-lateral margins. Mesonotum, margins white and not heavily chitinized. General color of central portion light brown, mottled with darker; two transverse dark brown spots at anterior margin of this central area. An irregular pale line curving posteriorly in the center divides this area transversely into a narrow paler posterior portion. The anterior portion is bisected longitudinally at another pale line and is bordered laterally by setae. Metanotum, membranous, white; a tuft of setae on each side of the median line and approximately one-third of the distance from anterior margin to posterior. The ventral surface of all thoracic segments is membranous and white. No prosternal horn. Legs yellow. Tibiae of front and middle legs with a spur bearing prominence.

Abdomen white. Dorsal spacing hump very large, capable of being distended or retracted. Lateral humps flattened. Gills branched on anterior segments. In some specimens gills are lacking on dorsum of sixth and seventh abdominal segments. Chitinous plate on dorsum of ninth segment yellow, bearing six heavy setae on posterior margin. Prolegs and draghooks pale yellow with strong setae.

Food. The few stomachs examined contained midge larvae, Diffugia and diatoms. Midge larvae were present in all stomachs examined and formed from fifty to sixty per cent. of the stomach contents by bulk. This species, then, seems to be a carnivore.

*Description of pupa.* Only a few pupae were obtained and since all of these were allowed to emerge, no material on which to base a color description is available. Length 11.3 to 12 mm.

Head with few setae. Antennae extending to eighth abdominal segment.

Tarsi of hind legs with swimming fringes. Lateral fringe begins on the third segment and loops under the eighth segment, becoming much heavier there. Dorsal spines as follows: III, 6. IV, 6. V, 6; 7-8. VI, 6-7. Anal appendages straight and slender. Each is armed at the caudal end with two curved yellow spines and is covered on its inner surface with short, heavy, anteriorly directed spines. Gills as in the larva; no gills on first abdominal segment.

*Description of pupal case.* The larval case is prepared for pupation by closing the ends. I have no material to show the nature of the covering of the anterior end. The posterior opening is closed by a sheet of silk in which there is a vertical slit. The larval dejecta are apparently pushed out through this slit. The margins of the case become ragged and irregular soon after the larva closes it up.

This species lives from ten to fourteen days as a pupa.

### Sericostomatidae

#### *Phanopsyche grisea*

Larvae of this species were found in Inlet and Argus Brooks. The species was reared for the first time in 1924. One adult was taken on Argus Brook on August 27, while a large series of specimens were taken on Inlet Brook from September 9 to 21. It was curious that this species, while caught in large numbers by the water-pan light on Inlet Brook, never strayed as far as the Shack.

*Description of case.* Length of case 12 mm. Maximum breadth 1.7 mm. Minimum breadth 1 mm.

The case is square in cross section, composed of fragments of leaves and bark smoothly joined together. It tapers uniformly from the cephalic to the caudal extremity. One small case, 7 mm. long, had the fragments of bark, etc., laid on rather loosely and irregularly. Another case had a rounded cross section along its central part.

*Description of larva.* Length full grown 9 mm.

Head uniform dark brown without markings except a yellow eye ring. Mandibles black, right mandible with a pencil of hairs internally and one external setae, left mandible with pencil of hairs, but with two external setae. Labrum brownish yellow.

Pronotum chitinized, dark brown. Mesonotum chitinized, light brown. Metanotum membranous, white, with three pairs of setiferous chitin spots as follows: A pair of minute spots close to the median line and near the anterior margin of the segment; a pair of slightly larger spots near the middle of the segment, but farther removed from the median line. These each bear one black seta. The third pair are narrow, beginning at the anterior margin and continuing back to the level of the second pair of spots. These are very near the lateral

margin of the segment. They bear several black setae. Legs yellow and brownish yellow. Bases of coxae and coxa bearing pieces margined with black. Prosternal horn present.

Abdomen, dorsal spacing hump lacking. Lateral spacing humps bluntly pointed, small. Gills single. Lateral line very faint, of short white hairs. Chitinous plate on dorsum of ninth segment brownish yellow bearing four long black setae and a few smaller ones. Prolegs short, brownish yellow, basal segment with four very long black setae. Food consists of raspings of partly decomposed wood.

*Description of case.* Length of case 10 mm. Diameter of case 1.7 to 2 mm.

Case tapers slightly from middle to posterior end and is made of leaf fragments neatly joined together. The pupal case is nearly circular in cross section, while the young larvae, at least have cases that are distinctly square in cross section. The ends are closed with silken gratings. Length of pupa 5⅓ mm.

*Description of pupa.* The color varies greatly with the age of the pupa. Newly formed pupae are nearly colorless while mature pupae become very dark.

Labrum about as broad as long with a mustache of eight or ten black bristles. Mandibles slightly curved, with a swollen base, then tapering quickly to a slender point, a pair of short black bristles on outer side of each mandible at base. Antennae only slightly longer than body.

Anterior coxae with three to four black bristles; middle coxae with two or three; posterior coxae with none.

First abdominal tergite. Posterior side produced at each lateral angle into a short process projecting postero-lateral. Lateral fringe present, black. Dorsal spines as follows: III, 3. IV, 3-4. V, 3; 6. VI, 3-4. VII, 3-4. Anal appendages rather short, stout and blunt, clothed with gray and fuscous hairs and terminated by four very long, heavy, black bristles on each appendage. Gills same as on larvae.

Description taken from two pupae—Inlet Brook, August 27.

## Limnophilidae

Twenty-six species of this family are now recorded from the reservation, and the majority of these have been reared.

This family, the largest in the order, still presents many problems in taxonomy. Among these is the question as to whether a difference in the number of spurs is a character of generic significance. Of course all female specimens are keyed to the family by their spur formula. If this is a character of value in separating families and it is repeatedly used for this purpose, then it should be of considerable value for separating genera.

However, in the genus Neophylax, the number of spurs varies considerably, and this raises questions as to the constancy of the spur formula in other genera.

The question has particularly been brought up as to whether the following were valid genera; Halesus spur formula 1-3-3; Platyphylax spur formula 1-2-2;

Stenophylax spur formula 1-3-4, and Pycnopsyche spur formula 1-3-4, but with the wing membrane granulate. Dr. Betten has already eliminated Pycnopsyche by placing its lone species, P. seabripennis in Stenophylax.

Now, if the spur formula of species in the remaining three genera varied, there would be sufficient reason for combining all these genera.

I had insufficient material of Platyphylax to test this, but of Halesus guttifer and Stenophylax scabripennis I had nearly one hundred specimens each. I examined these for variation in the size, arrangement and number of spurs and found the spurs to be remarkably constant on all three conditions. So I am forced to conclude that Halesus, Platyphylax and Stenophylax must still stand as distinct genera.

H. guttifer and S. scabripennis were found by Lloyd to be very closely related as larvae and he experienced great difficulty in distinguishing one from the other. The pupae also look very much alike. The only character I have to distinguish them is the spur formula. The dorsal spines of H. guttifer vary as follows: III, 2-4. IV, 2-4. V, 2-5; 10-12. VI, 2-5. VII, 2-4. The dorsal spines of S. scabripennis vary as follows: III, 2-4. IV, 2-5. V, 2-5; 9-18. VI, 2-5. VII, 3-6. Other pupal structures of the two species have a similar resemblance.

Other characters will be taken up in the description of various species.

The genus Neophylax is a difficult group so I am redescribing the adults of two of the three species recorded here. *N. autumnus* was described in detail by Vorhies and need not be redescribed.

### *Neophylax autumnus*

Reported by Lloyd from the Big Spring near headwaters of Beaver Creek. Found by us to be very abundant also in Inlet Brook. The larvae and prepupae were also found in Sphaerium Brook mingled with those of N. concinnus. Adults were reared from Inlet Brook on September 14, 17, 19 and 21. Of those which emerged on September 21, one male had a spur formula on one side of 1-2-3, and on the other of 1-2-2. The spur formula in all others was 1-2-4. Adults were taken in the tent trap on Inlet Brook on September 13, 15, 19, 20, 23. One was caught on Argus Brook September 20.

The anal appendage of the pupa is bulbous at the base, tapering gradually to a slender tip which is recurved laterally.

### *Neophylax concinnus*

Reported by Lloyd as very abundant in Sphaerium Brook, adults emerging about the first week of October and continuing on the wing until the middle of November. The specimens I have referred to this species appeared as follows: Sphaerium Brook, female, August 27; male, September 3; reared, male, September 6; The Hook, male, September 3.

*Description of adult.* Length of body, male, 6 mm. Length to tip of wings 11 mm. Length of body, female, 6.3 mm. Length to tip of wings 11.5 mm.

Head yellow with brown and golden hairs. Antennae stout, yellow, faintly annulate with brown. Palpi yellow with brown hairs.

Thorax brownish yellow above, yellow beneath. Legs yellow, covered with short, fine brown hairs. Spines black. Spurs yellow. Fore wings fuscous, guttate with cream. Costal and subcostal cells cream or pale yellow from base of wing to stigma. Anal area yellow, color extending up to or slightly beyond first anal. Wings covered with fine, brown hair, much shorter and less profuse than in N. autumnus, Vorhies. Hind wings hyaline, veins yellow, pubescence yellow and fringe yellow.

This species may be distinguished from the other two of the genus here mentioned by the fact that in the hind wing, in the male, the pedicel of the discal cell is either very short or lacking entirely, that is, the branches of radial sector have either split nearly to $R_1$ leaving a very short stem of Rs or have split all the way to $R_1$ so that $R_{2}$-$_{3}$ and $R_{4}$;$_{5}$ arise separately from $R_1$. The short stemmed radial sector is the common condition in the material I have. The stem of media is lacking and the branches of media are almost completely fused with adjacent veins as is the case in the other two species mentioned here.

The wings of the female are normal for the genus, that is, four branched radial sector and two branched media in the hind wing. Females can be distinguished from those of the other two species by the sparse hairing and distinct light spots of the fore wings.

The color description is from a male in alcohol.

*Description of pupa.* Length 8 mm.

Labrum about as broad as long, rounded in front. Mandibles of the family type, broad, tapering regularly. Antennae longer than the body, recurved cephalad on each side of the anal appendages. Caudal border of first abdominal tergite; the dark band is wider than in N. autumnus. Dorsal spines as follows: III, 5-6. IV, 6-7. V, 5-7; 30-32. VI, 6-8. VII, 8-11. Anal appendages similar to those of N. autumnus.

### *Neophylax fuscus*

Inlet Brook, September 20 and 21.

*Description of the adult.* Wing expanse 17 mm. Length to tip of wings 9 mm., male. Length of body 5 mm., male.

Head brownish yellow. A row of black bristles on front along margin of eye; shorter white hairs on median portion of front; vertex with white hairs. Genae bluntly produced; labrum short. Antennae stout, brownish yellow.

Thorax yellow; legs yellow, tinged with brown. The second to fifth segments of the hind tarsi with a black stripe on the upper (outer) surface. Fore wings ground color fuscous, faintly guttate with white; covered with golden brown hairs except in anal area which is covered with golden hairs up to first anal.

Hind wings white to hyaline. In all males the stem of media is lost and the branches of media have almost completely fused with $R_5$ and $Cu_1$ so that the remnant appears like a cross-vein. In some specimens this remnant is bent above its middle towards the base of the wing and at this point a stub of media still persists. In other specimens it appears only as a slightly curbed cross-vein. Spurs 1-2-3, yellow. Inner distal spur on hind tibia with a thin blade-like dilation. Abdomen ferruginous.

*Astenophylax Argus*

This species was reared by J. T. Lloyd, and an excellent account of the life history is to be found in his paper.* Argus Brook was so named because of the abundance of this species there. We have very little to add to Lloyd's account. In 1924, the species was more common in Sphaerium Brook than in Argus. We also found a few specimens in Inlet Brook. Most of the adults appeared on June 12 and 13, but we took an adult on July 2 and another on July 8, showing that the species may emerge over a longer period than hitherto thought.

*Descriptive note on pupa.* Length 22 mm. Notch in tergite very deep, narrow, parallel sided. Dorsal spines as follows: III, 6. IV, 6. V, 7-9; 26-27. VI, 5. VII, 7-8.

*Platycentropus maculipennis*

J. T. Lloyd reared this species and reported it as very abundant in Argus Brook and the upper part of Sphaerium Brook. In addition we found it to be very common in Mud Pond where the larvae attach their cases to the root of the loose strife clumps preparatory to pupation. The period of emergence is given by Lloyd as around the middle of July. We reared specimens from Mud Pond on July 21 and 24, but we also had them from Sphaerium Brook as late as August 16. Specimens were taken on Argus Brook, Sphaerium Brook and Mud Pond.

*Description of pupa.* Length 15 mm.

Antennae extending to anterior margin of eighth segment. Labrum broader than long, rounded in front, with two groups of fuscous setae.

First abdominal tergite with a group of four black setae on each side near the posterior-lateral margin. Lobes of the caudal margin slightly produced, the notch a broad V. Gills in bunches as in the larva. Dorsal spines as follows: III, 1. IV, 1-2. V, 2; 14. VI, 2. VII, 2. Lateral line black, begins on caudal portion of fifth segment and loops under eighth segment along its caudal margin. Anal appendages slender, divergent at tips, somewhat broader there; covered near tips with spines, and with two black setae on tips.

*Limnophilus pulchellus*

This species was first found at McLean on June 2, 1923, by the author. During the season of 1924 we found it at Mud Pond, Sphaerium Brook, Grass

* Lloyd Libr. Bull. 21: 57-60. 1921.

Bog 2 and the Shack. Dates of capture range from May 26 to June 26. The species was fairly common during this time.

One male taken June 2, 1923, showed an interesting variation in that the discal cell was open in all four wings.

### *Platyphylax lepidus*

This species was reared by us for the first time. Adults were taken at Mud Pond, Sphaerium Brook and the Shack. Reared specimens emerged on August 17 and 21. Dates of capture of the other specimens range from August 11 to September 21.

The larvae of this species were found in the gravelly part of Sphaerium Brook, together with several other large Limnophilidae. However, this species was quite rare as compared with *Stenophylax scabripennis* or *Halesus guttifer*.

*Description of case.* The case is a cylinder composed of large pieces of bark and wood quite smoothly fastened. Before sealing the case for pupation the larva may fasten a pebble at one end. The posterior end of the case is rounded and sealed with a small grating containing four or five holes while the anterior end is closed by a larger grating having many holes.

*Description of larva.* Length 16 mm.

Head brown with mottling besides muscle attachment marks. Mottled with dark brown to black along the lateral margins of the frons. Frons brown, mottled with dark brown as indicated in the figure (98). Labrum brown, anterior margin brownish black. Mandibles black, broad, of similar shape; each with a small brush of pale hairs internally.

Pronotum brown, mottled with dark brown, posterior margin black. Mesonotum brown, mottled with dark brown, a transverse band brownish black and posterior margin black. Metanotum with three pairs of black chitinous plates in the arrangement characteristic for the family.

Abdomen yellowish. Spacing humps; all humps flattened. Draghooks dark brown, with one dorsal spine. Gills single.

*Description of pupa.* Length 18 mm.

Color white. Antennae about as long as body. Labrum with two groups of black setae. Mandibles straight, tapering from a swollen case. Gills arising singly, as in larva. Spur formula 1-2-2 as in adult. Dorsal spines as follows: III, 2-3. IV, 2-3. V, 3; 6-12. VI, 3-4. VII, 3. Lateral line begins on the fifth segment and loops under the eighth. Anal appendages of the characteristic type except for a slight upcurving at the tips. Length 1.1 mm.

The caudal surface of the ninth abdominal segment is covered with numerous minute spines.

### *Leptophylax gracilis*

This species was taken at light at the Shack from June 23 to July 22, the maximum number being taken on the first night.

In the large series I have taken, cell $M_1$ is not always pedicellate so that many specimens would not run to the genus correctly by the keys, in spite of the fact that color and male genitalia are the same.

There are two black spines on the last segment of the hind tibiae in my material.

*Halesus guttifer*

This species was as abundant as was *Stenophylax scabripennis* in Sphaerium Brook. Reared specimens emerged from August 26 to September 17. The species was also taken at the Shack, Inlet Brook and Grass Bog 3. Dates range from August 26 to September 23.

Pupae, as well as adults, of Halesus, Stenophylax and Platyphylax may be separated definitely only by the spur formulas 1-3-3, 1-3-4 and 1-2-2, respectively. As yet no characters have been found to divide the larvae into groups corresponding to the adult genera.

*Description of pupa.* Length 17 mm.

Labrum with two groups of heavy black setae as in *S. scabripennis.* Mandibles with a swollen base and a broad, straight tapering blade. Two external setae at base. Spur formula 1-3-3. Dorsal spines as follows: III, 2-4. IV, 2-4. V, 2-5; 10-19. VI, 2-5. VII, 2-4. Lateral line begins near anterior margin of sixth segment and loops under eighth segment near posterior margin. Anal appendages as in *S. scabripennis,* long, slender and slightly upturned at tips; ninth segment with minute spines as in related genera, but having also two groups of black setae beneath.

*Stenophylax gentilis*

Reared in Inlet Brook. Adults were taken in Inlet Brook from September 14 to September 20.*

*Description of case.* Length 20 mm. Breadth 6 mm.

The case is a cylinder covered with small pebbles. The ends are closed with gratings of the ordinary type before pupation. The posterior grating is placed a little inside the case and is protected by a large stone that nearly covers the posterior end of the case.

*Description of larva.* Length 14 mm.

Head, brownish yellow, muscle attachment marks darker. Frons brown, except anterior margin which is brownish yellow. Labrum yellowish brown, broadly emarginate. Mandibles black, each with an internal brush of pale hairs.

Pro- and mesonotum chitinized, yellowish brown, posterior margin black. Metanotum with the three pairs of chitinous plates of the family. Prosternal horn present. Gills single; arranged as in *S. scabripennis.* Spacing humps rounded.

---

*A male of this species remained alive in captivity for 125 hours. At the end it could still move the legs and abdomen but could not stand or walk. The temperature was low during this period.

*Description of pupa.* Length 16 mm.

Color white. Antennae reaching to end of body. Mandibles straight, tapering regularly to tip from a swollen base. Labrum with two groups of brown setae. Spur formula 1-3-4 as in adult. Dorsal spines as follows: III, 5. IV, 5. V, 5; 12-13. VI, 4. VII, 5-6. Gills arising singly as in the larva. Lateral line begins at anterior margin of sixth segment and loops under eighth segment along its caudal margin. Anal appendages. While of the family type the anal appendages of this species are shorter than in Platyphylax lepidus and Stenophylax scabripennis. The length is about .6 mm. Also they are straight and slightly knobbed at their tips.

### *Stenophylax scabripennis*

This species was reported by Lloyd as common in Sphaerium and Argus Brooks; the adults appearing in late August and early September. We found them also very common in Inlet Brook. Our records for adults range from July 11 to September 21. Adults were taken at the Shack, Mud Pond, Inlet Brook and Sphaerium Brook. On Sphaerium Brook most adults appeared between August 13 and 26; on Inlet Brook, September 9 and 13.

*Description of pupa.* The pupa of this species resembles that of *Platyphylax lepidus* and of *Halesus guttifer,* but may be readily distinguished by the spur formula 1-2-4. Dorsal spines as follows: III, 2-4. IV, 2-5. V, 2-5; 9-18. VI, 2-5. VII, 3-6. Lateral line begins slightly caudad of the anterior margin of the sixth segment and loops under the eighth segment.

## MISCELLANEOUS NOTES

*Parasitism of Trichoptera.* The only internal parasite of Trichoptera thus far recorded is a species of Agriotypus. This little hymenopterous insect has been found only in Europe, where it is quite a common parasite of several genera of Trichoptera which have stone cases and which live in rather swift water. The host is finally destroyed after it has attached its case preparatory to pupation. The parasite then rapidly completes its growth and spins a two-layered cocoon of silk within which it pupates. This cocoon occupies nearly the entire host case with exception of a small space at the posterior end filled by the remains of the host larva. A long ribbon of silk protrudes from the anterior end of the parasitized cases making them easily recognizable. This parasite has not been found in America as yet.

During the past summer I found a case of *Platycentropus maculipennis* of the Limnophilidae which contained a Hymenopterous parasite differing markedly in habits from Agriotypus. On July 28 a case was taken from Sphaerium Brook which while normally closed for pupation contained a shrivelled pupal skin and a large Hymenopterous larva, evidently a parasite. Unfortunately the caudal end of both host and parasite case was torn off when the case was removed from its support.

The shrivelled pupa of the host occupies the anterior half of the case while the parasite fills the posterior half. The parasite larva is enclosed in a cylindrical cocoon of tough black silk, in two layers. This cocoon is entirely closed and fits tightly in the host case. It is probable that the dejecta of the host was in the posterior end of the case.

*Description of case.* Length of host case 16 mm. Outside diameter 5 mm. Length of cocoon of parasite 8 mm. Outside diameter 3.5 mm. Length of parasitic larva (curled as in case) 7 mm.

It will be noticed that the host was killed after it had pupated and that the cocoon of the parasite occupied only half of the host case.

While but one specimen was found at that time, additional specimens of a similar type have since been found at Ringwood Hollow, near Ithaca, N. Y. The parasite has not yet been reared.

*Parthenogenesis in the Trichoptera.* A large series of *Psychomyia flavida* was taken at light during the summer, eight hundred and ninety-three specimens in all. I was surprised to find that every individual of this series was a female. Hagen's type was a female and Dr. Betten has seen only females of this species. So it seems very probable that this is a parthenogenetic species like the European *Apatania muliebris* of the Limnophilidae.

*The Chrysopa-like odor of certain Limnophilidae.* McLachlan reports that adults of the genus Anabolia give off a strong, rather unpleasant odor. During

the past summer we noticed that both sexes of *Stenophylax* give off a very noticeable odor. This is sufficiently strong to be noticed when the insect flies within a foot of one's head.

## Bibliography

Of works consulted in preparing the keys

Betten, C. Trichoptera; *in* Aquatic insects of the Adirondacks, by J. G. Needham *and others,* Bull. 47, New York State Museum, Albany, 1901, pp. 573-591.

Klapalek, Fr. Agriotypus armatus; its life history and geographical distribution, Ent. Month. Mag., 25: 339-343, 1888-89.

Lestage, J. A. Trichoptera; *in* Les larves et nymphs aquatiques des insects d'Europe, by E. Rousseau *and others,* Brussels, pp. 343-964, 1921.

Lloyd, J. T. Wood-boring Trichoptera. Psyche, 22: 17-21, 1915.

Lloyd, J. T. Notes on the Immature Stages of some New York Trichoptera, Jour. N. Y. Ent. Soc., 23: 201-212, 1915.

Lloyd, J. T. The Biology of North American Caddisfly larvae, Bull. 21 (Ent. series No. 1), Lloyd Library, Cincinnati, O., 124 pp., 197 figs., 1921.

Morton, K. J. North American Hydroptilidae, N. Y. State Museum Bull., 86: 63-75, plates 13-15, 1905.

Silvenius, A. J. Ueber die Metamorphose einger Hydroptiliden, Acta Soc. pro Faune et Flora Fennica, 26, No. 6, 38 pp., 1904.

Thienemann, Aug. Biologie der Trichopterenpuppen, Zoolog. Jahrb., Abteil. f. System., Geog. u. Biol. der Tiere, 22: 489-574, 1905.

Ulmer, G. Trichoptera in Susswasserfauna Deutschlands, Vols. 5-6, pp. 283-321, 1909.

Vorhies, C. T. Studies on the Trichoptera of Wisconsin, Trans. Wisc. Acad. of Science, Arts and Letters, 16: 647-718, 1909.

Plate I

Fig. 1. *Onygens equine* on cow's hoof.

Fig. 2. Same on cow's horn.

Fig. 3. *Melanospora parasitica* on *Isaris sp.*

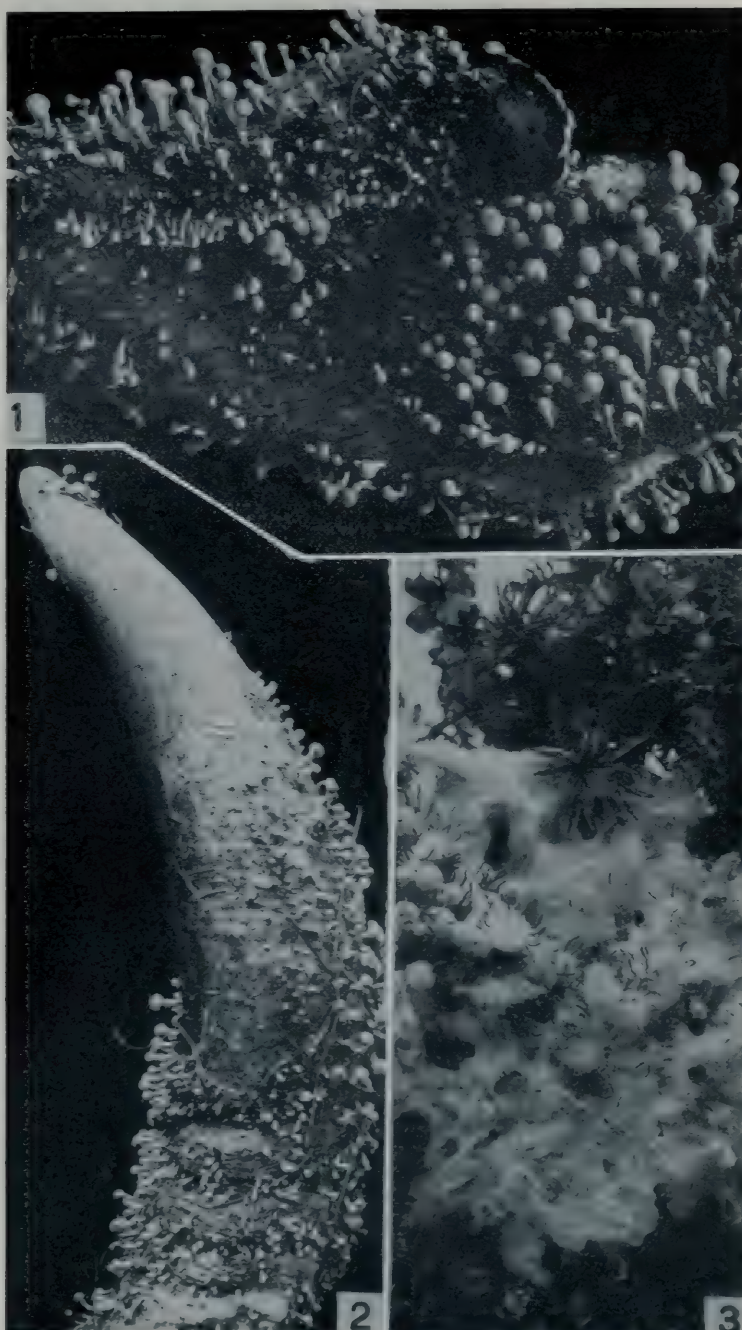

1
2
3

Plate II

Fig. 4. *Collybia tuberosa.*

Fig. 5. *Cordyceps capitata* on *Elaphomyces granulatus.*

Fig. 6. *Cordyceps militaris* on pupa.

Fig. 7. Conidial stage (*Isaria farinosa*) of *Cordyceps militaris* on pupa.


4
5
6
7

PLATE III

Fig. 8. *Puccinia podophylli* (I) on sepals and leaves of *Podophyllum peltatum.*

Fig. 9. *Exobasidium vaccinii* on *Rhododendron nudiflorum.*

Fig. 10. *Acetabula sulcata* on ground.

Fig. 11. *Sclerotinia vaccinii-corymbosi* on *vaccinium corymbosum.*

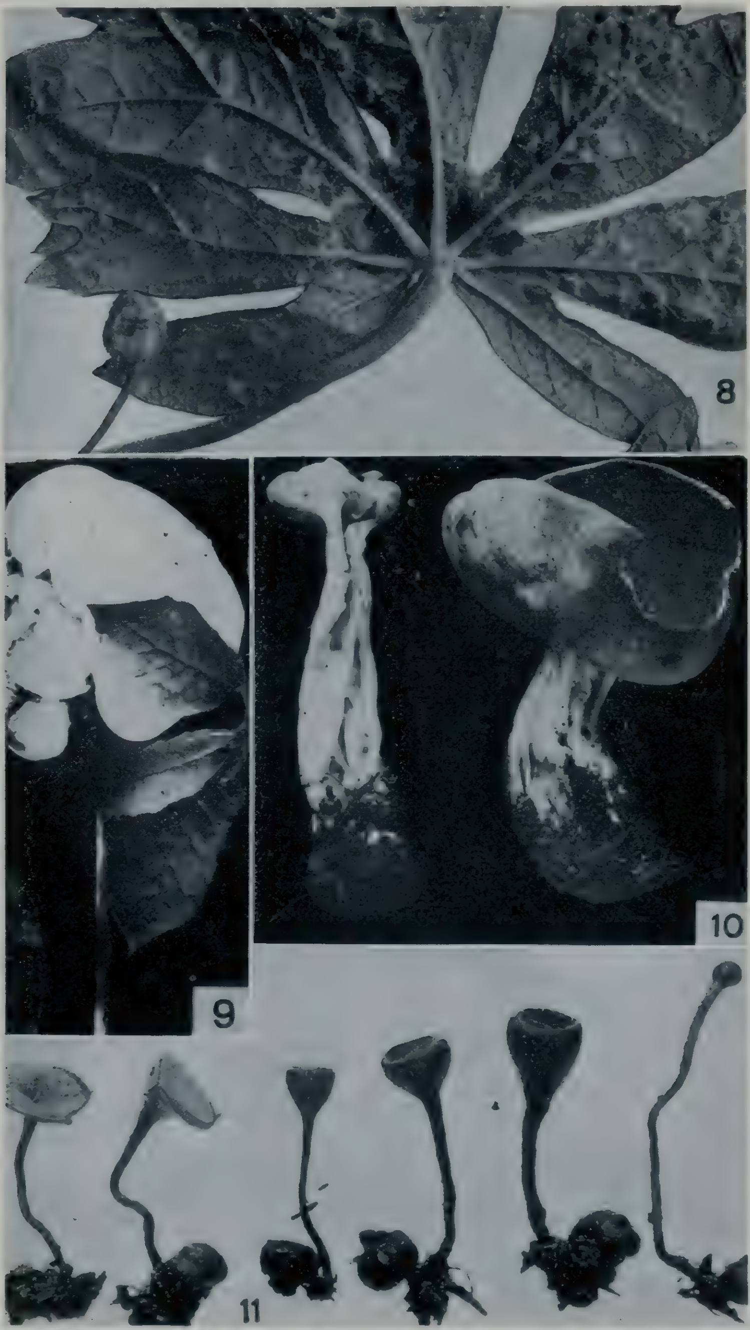

8
9
10
11

Plate IV

Fig. 12. Border of Mud Pond in late spring; Decodon clumps in foreground; inlet at right; outlet at left.

Fig. 13. Border of Mud Pond, late August.

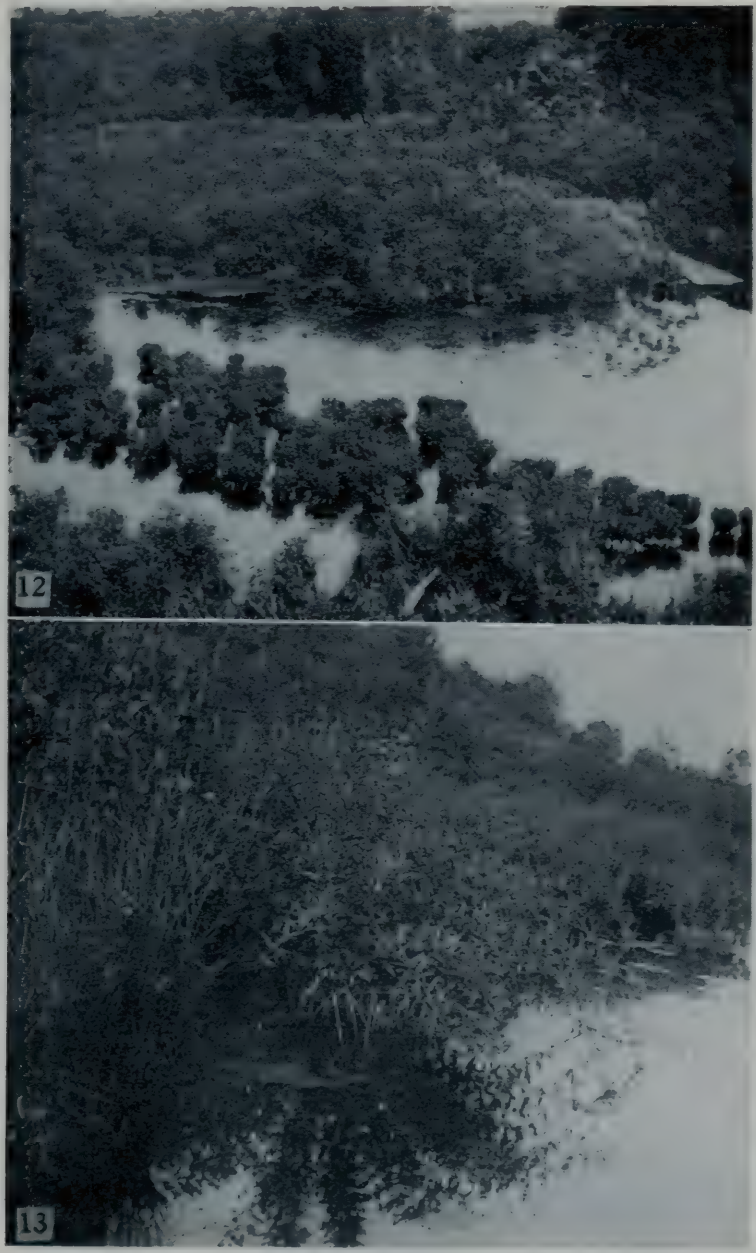

12
13

Plate V

Fig. 14. Grass Bog No. 1.

Fig. 15. Tent trap set in Inlet Brook.


14

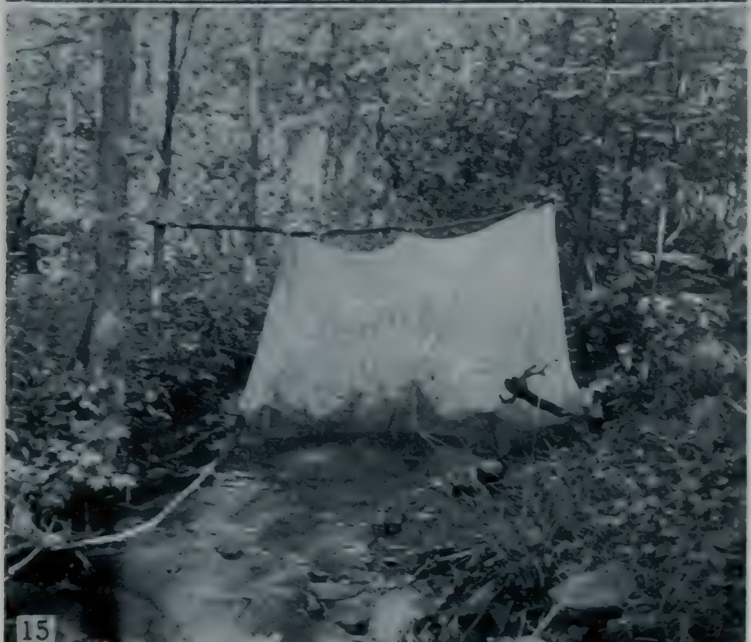

15

PLATE VI

Fig. 16. Larval cases of *Molanna blenda,* ventral view.

Fig. 17. Larval cases of *Molanna blenda,* dorsal view.

Fig. 18. Jefferson's salamander (*Ambystoma jeffersonianum*).

Fig. 19. Redbacked salamander (*Plethodon cinareus*) in nest in rotten log.

PLATE VI

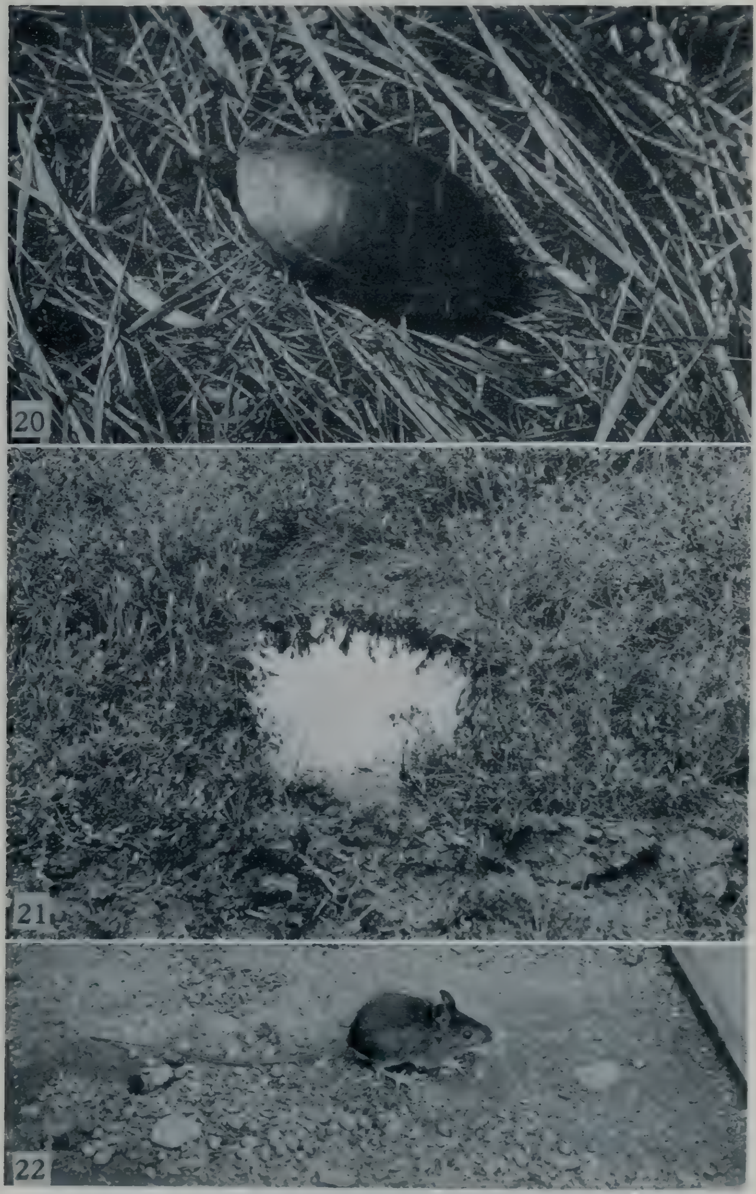
PLATE VII

Fig. 20. Western painted turtle (*Chrysemys marginata*) in grass bog.

Fig. 21. Hole in the bog cover (Bog B), where bottle-traps were set.

Fig. 22. Meadow jumping mouse, *Zapus hudsonius*.

# PLATE VII



## Plate VIII

Fig. 23. *Agapetus minutus,* larva; dorsal aspect of head.

Fig. 24. *Agapetus minutus,* larva; dorsal aspect of thorax.

Fig. 25. *Agapetus minutus,* larva; dorsal aspect of labrum.

Fig. 26. *Agapetus minutus,* pupa; caudal of abdomen.

Fig. 27. *Agapetus minutus,* male genitalia, lateral aspect.

Fig. 28. *Agapetus minutus,* pupa; right mandible.

Fig. 29. *Agapetus minutus,* larva; right mandible.

Fig. 30. *Agapetus minutus,* larva; left mandible.

Fig. 31. *Agapetus minutus,* adult male; wings.

Fig. 32. *Mystrophora americana,* pupa; right mandible.

Fig. 33. *Mystrophora americana,* pupa; labrum.

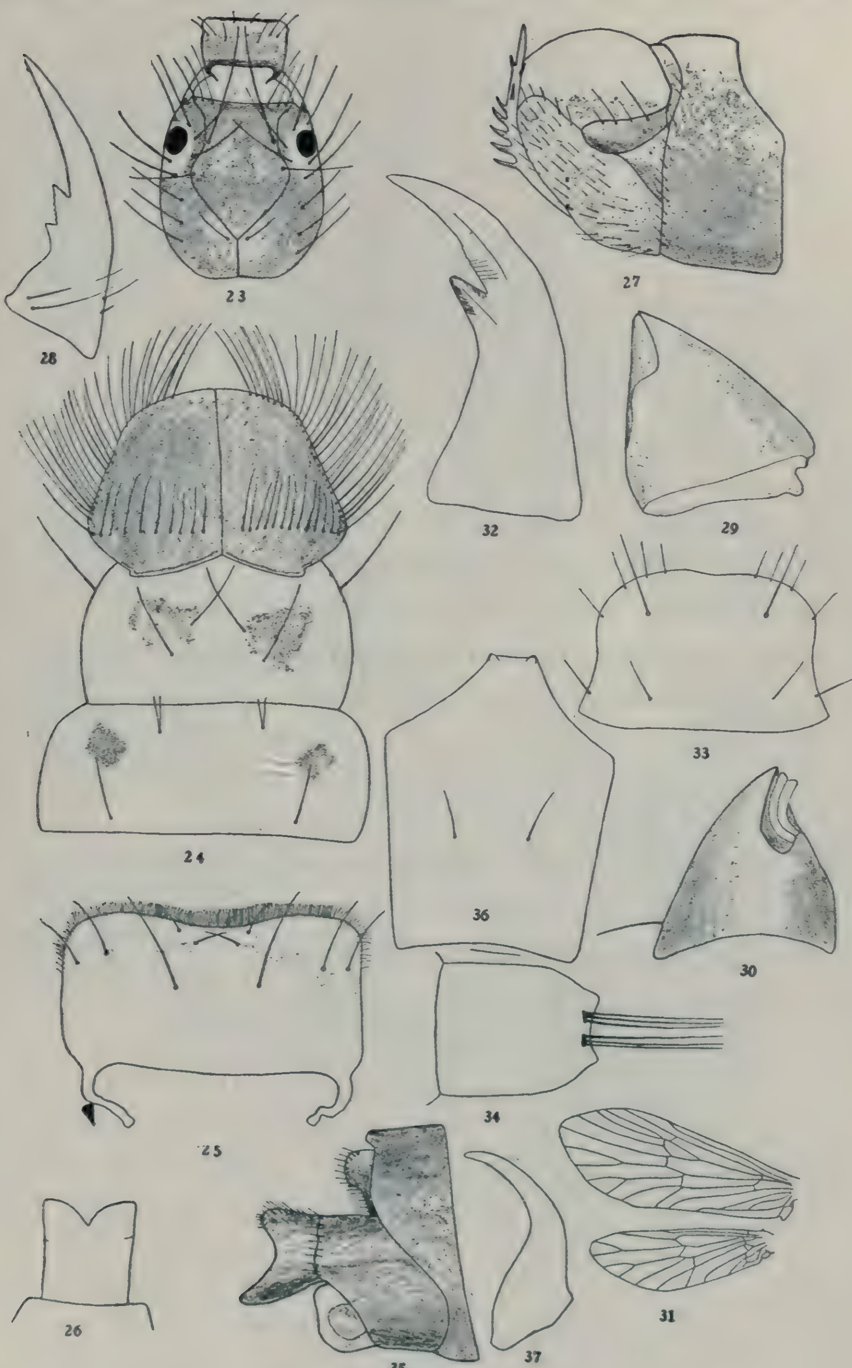
Fig. 34. *Mystrophora americana,* pupa; end of abdomen.

Fig. 35. *Rhyacophila gordoni,* male; genitalia latent aspect.

Fig. 36. *Neuronia postica,* pupa; first abdominal segment.

Fig. 37. *Phryganea interrupta,* pupa; right mandible.

# PLATE VIII



## Plate IX

Fig. 38. *Hydroptila delineata,* larva; dorsal aspect of head.

Fig. 39. *Hydroptila delineata,* larva; left mandible.

Fig. 40. *Hydroptila delineata,* larva; right mandible.

Fig. 41. *Hydroptila delineata,* larva; dorsal aspect of thorax.

Fig. 42. *Hydroptila delineata,* pupa; right mandible.

Fig. 43. *Oxethira dualis,* larva; head and thorax.

Fig. 44. *Oxethira dualis,* pupa; right mandible.

Fig. 45. *Phanopsyche grisea,* larva; dorsal aspect of head.

Fig. 46. *Phanopsyche grisea,* larva; dorsal aspect of thorax.

Fig. 47. *Phanopsyche grisea,* larva; left mandible.

Fig. 48. *Phanopsyche grisea,* larva; right mandible.

Fig. 49. *Phanopsyche grisea,* larva; arrangement of gills.

Fig. 50. *Phanopsyche grisea,* larva; frons.

Fig. 51. *Phanopsyche grisea,* larva; female pupa and appendage.

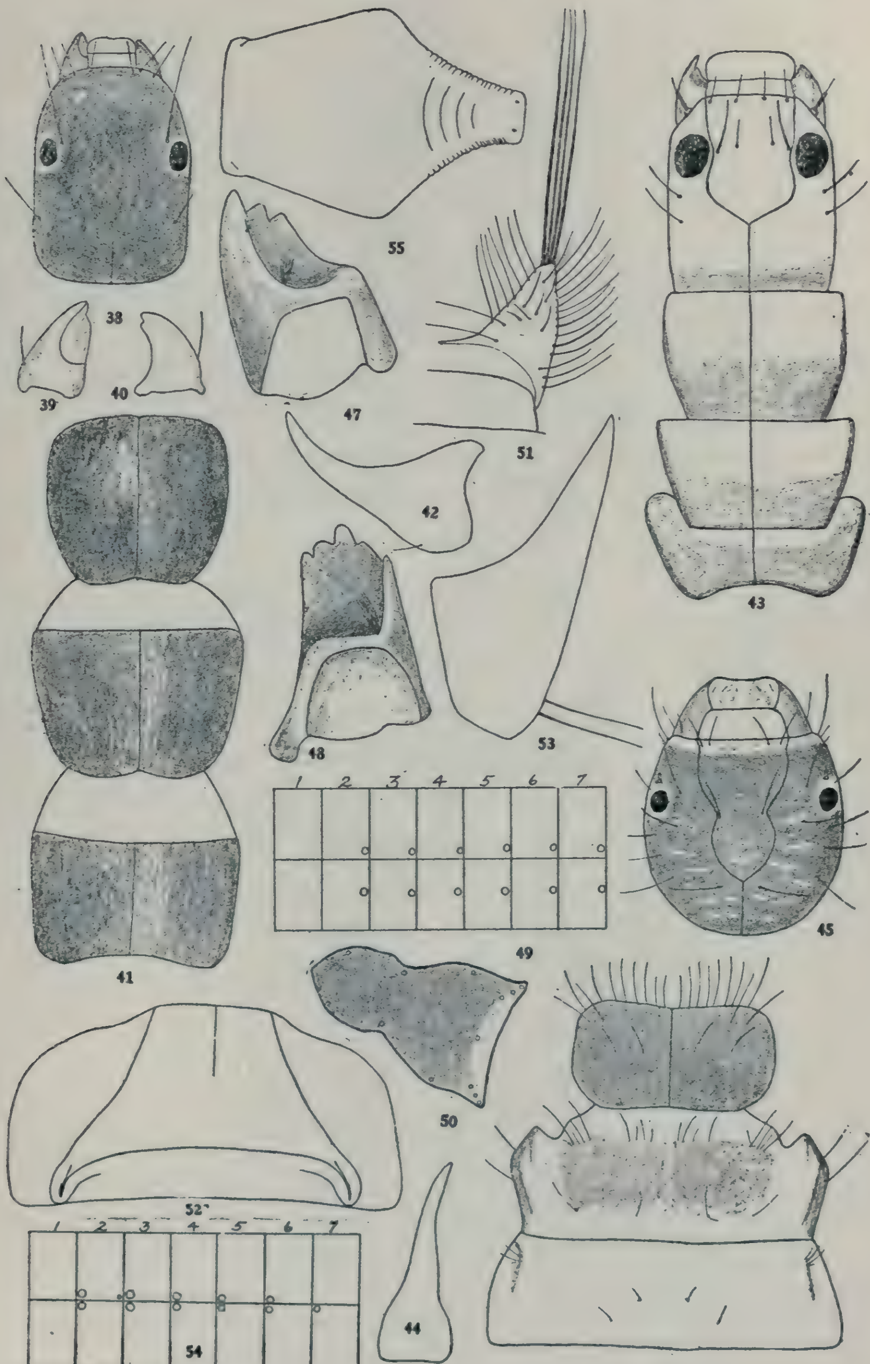
Fig. 52. *Phanopsyche grisea,* pupa; first abdominal tergite.

Fig. 53. *Phanopsyche grisea,* pupa; right mandible.

Fig. 54. *Triaenodes marginata,* larva; arrangement of gills.

Fig. 55. *Phryganea interrupta,* pupa; first abdominal tergite.

# PLATE IX


38
39
40
41
42
43
44
45
46
47
48
49
1 2 3 4 5 6 7
50
51
52
53
54
1 2 3 4 5 6 7
55

## Plate X

Fig. 56. *Phylocentropus lucidus,* larva; dorsal aspect of head.

Fig. 57. *Phylocentropus lucidus,* larva; dorsal aspect of thorax.

Fig. 58. *Phylocentropus lucidus,* larva; dorsal left mandible.

Fig. 59. *Phylocentropus lucidus,* larva; dorsal right mandible.

Fig. 60. *Phylocentropus lucidus,* larva; mesothoracic leg.

Fig. 61. *Phylocentropus lucidus,* proleg.

Fig. 62. *Phylocentropus lucidus,* pupa; end of abdomen.

Fig. 63. *Phylocentropus lucidus,* pupa; left mandible.

Fig. 64. *Agraylea multipunctata,* pupa; left mandible.

Fig. 65 *Chimarrha aterrima,* pupa; right mandible.

Fig. 66. *Psilotreta frontalis,* pupa; right mandible.

Fig. 67. *Psilotreta frontalis,* pupa; anal appendage.

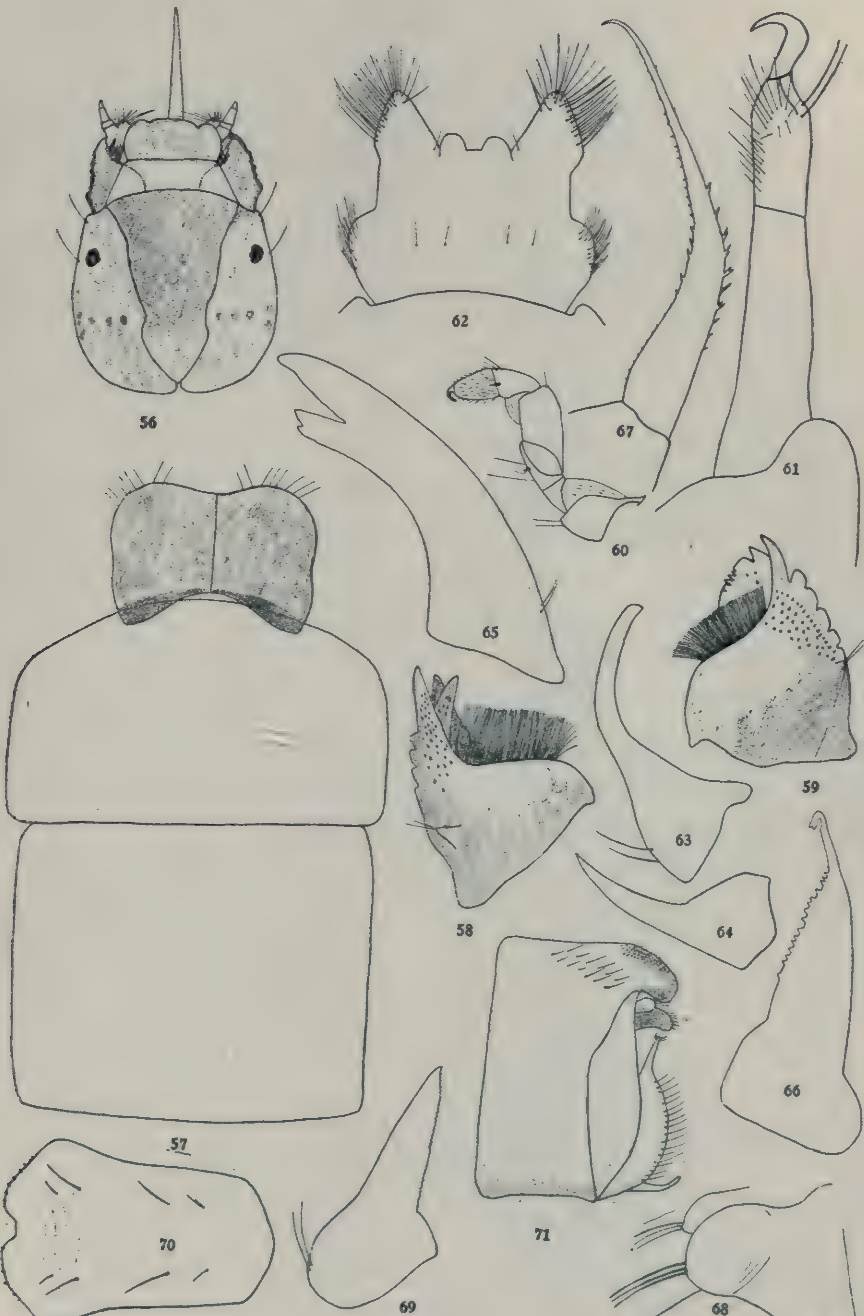
Fig. 68. *Neuronia postica,* pupa; anal appendage.

Fig. 69. *Halesus guttifer,* pupa; left mandible.

Fig. 70. *Halesus guttifer,* pupa; first abdominal tergite.

Fig. 71. *Halesus dan,* male; genitalia, lateral aspect.

# PLATE X



## Plate XI

Fig. 72. *Triaenodes marginata,* larva; head.

Fig. 73. *Triaenodes marginata,* larva; thorax.

Fig. 74. *Triaenodes marginata,* lateral aspect of head

Fig. 75. *Triaenodes marginata,* left mandible.

Fig. 76. *Triaenodes marginata,* right mandible.

Fig. 77. *Triaenodes marginata,* drag hook.

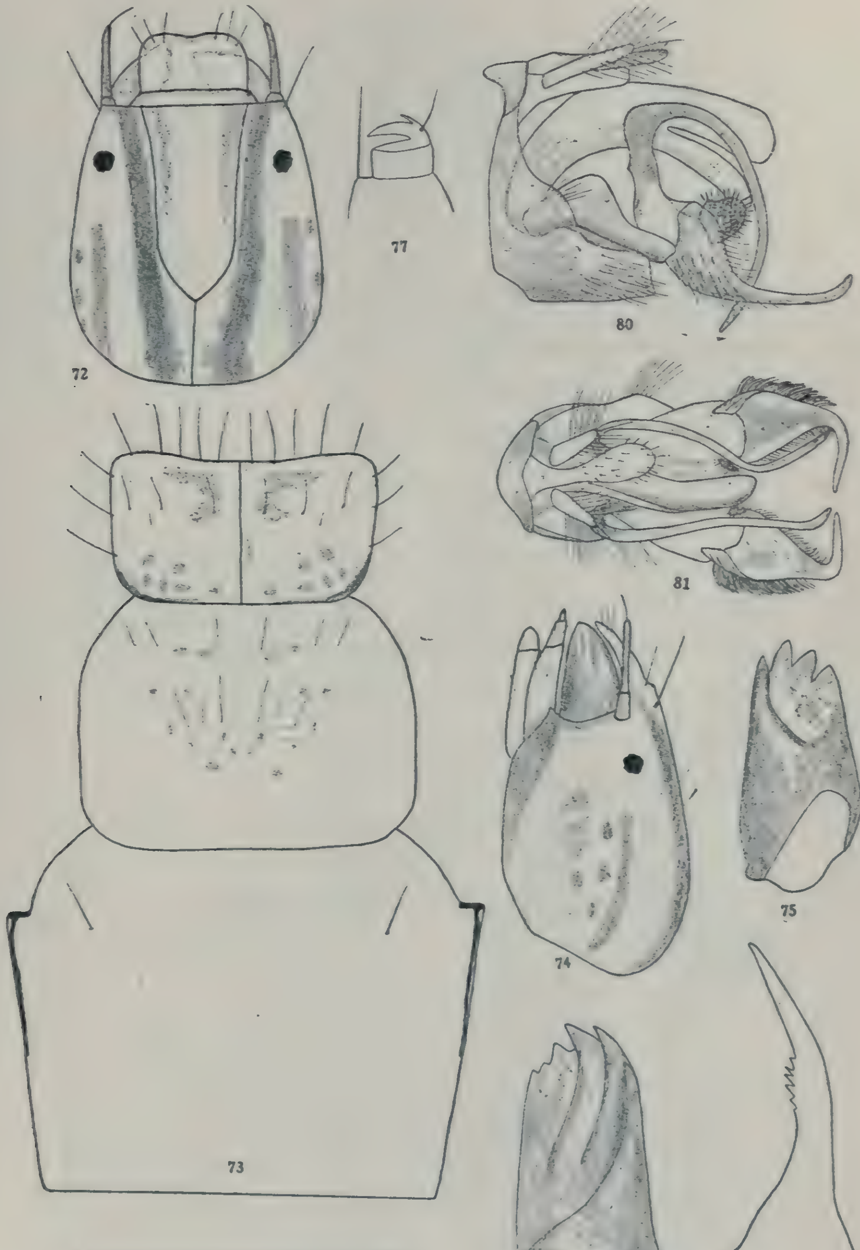
Fig. 78. *Triaenodes marginata,* pupa; anal appendages.

Fig. 79. *Triaenodes marginata,* pupa; right mandible.

Fig. 80. *Triaenodes marginata,* male genitalia; lateral aspect.

Fig. 81. *Triaenodes marginata,* male genitalia; postero-dorsal.

# PLATE XI



## Plate XII

Fig. 82. *Molanna blenda,* larva; head.

Fig. 83. *Molanna blenda,* larva; thorax.

Fig. 84. *Molanna blenda,* larva; left mandible.

Fig. 85. *Molanna blenda,* larva; right mandible.

Fig. 86. *Molanna blenda,* larva; fore leg.

Fig. 87. *Molanna blenda,* larva; middle leg.

Fig. 88. *Molanna blenda,* larva; hind leg.

Fig. 89. *Molanna blenda,* larva; dorsal spacing hump.

Fig. 90. *Molanna blenda,* larva; arrangement of gills.

Fig. 91. *Molanna blenda,* pupa; right mandible.

Fig. 92. *Molanna blenda,* pupa; end of abdomen.

Fig. 93. *Neuronia postica,* pupa; labrum.

Fig. 94. *Neuronia postica,* pupa; left mandible.

Fig. 95. *Stenophylax scabripennis,* pupa; anal appendage.

PLATE XII

## Plate XIII

Fig. 96. *Platphylax lepidus,* larva; head.

Fig. 97. *Platphylax lepidus,* larva; thorax.

Fig. 98. *Platphylax lepidus,* larva; frons.

Fig. 99. *Platphylax lepidus,* larva; arrangement of gills.

Fig. 100. *Stenophylax gentilis,* larva; head.

Fig. 101. *Stenophylax gentilis,* larva; thorax.

Fig. 102. *Stenophylax gentilis,* pupa; anal appendage.

Fig. 103. *Neophylax fuscus,* wings of male.

Fig. 104. *Neophylax autumnus,* pupa; first abdominal tergite.

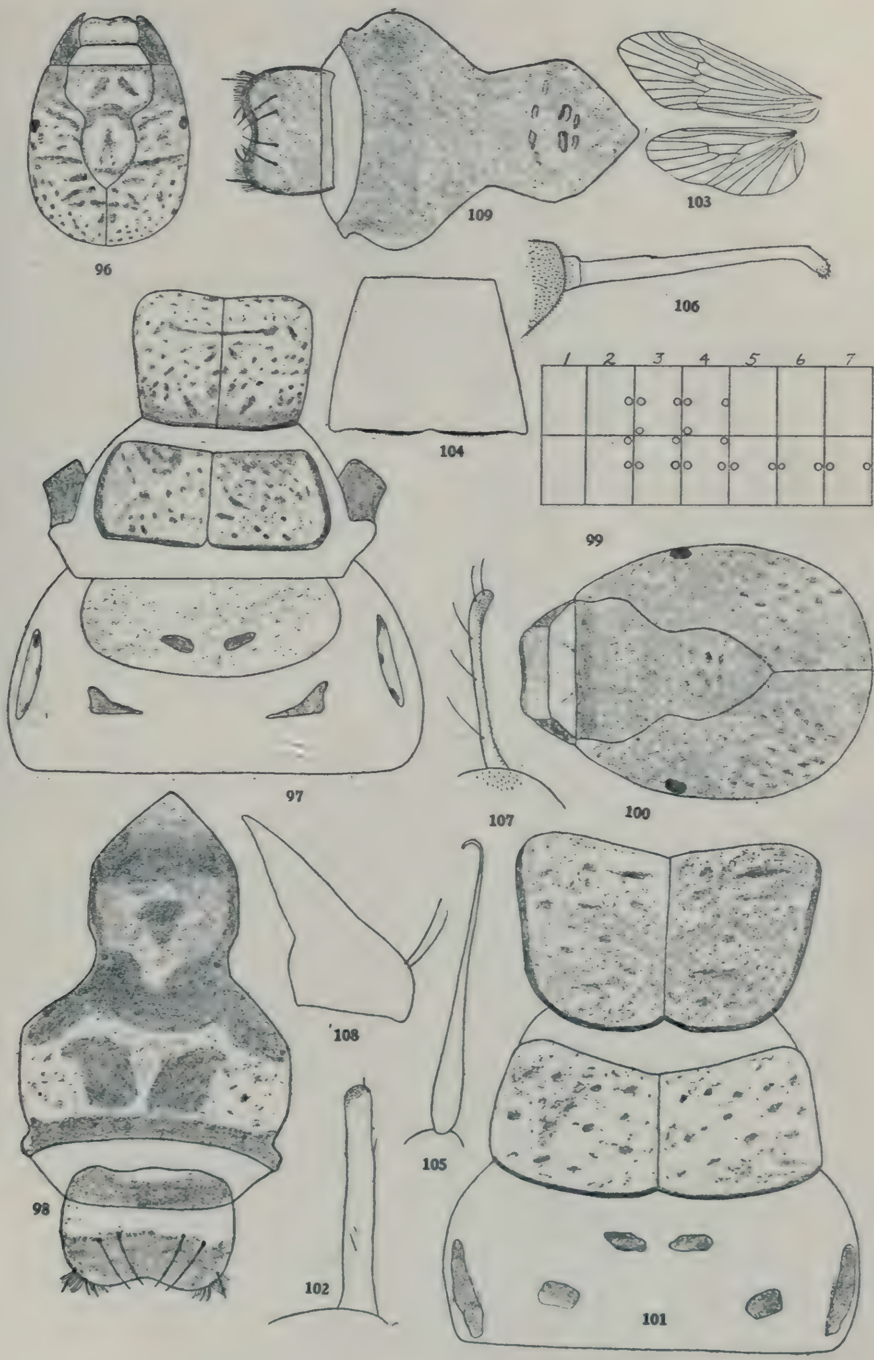
Fig. 105. *Neophylax autumnus,* pupa; anal appendages.

Fig. 106. *Chilostigma difficile,* pupa; anal appendages.

Fig. 107. *Platycentropus maculipennis,* pupa; anal appendages.

Fig. 108. *Platycentropus maculipennis,* pupa; right mandible.

Fig. 109. *Stenophylax gentilis,* larva; frons.


96
109
103
106
104
1 2 3 4 5 6 7
99
97
107
100
98
108
105
102
101

749

## Publications Issued by the Lloyd Library

(Continued)

No. 14. MYCOLOGICAL SERIES No. 5.
Synopsis of the Genus Hexagona, by C. G. Lloyd.

No. 15. BOTANY SERIES No. 1.
Catalogue of the Ferns and Flowering Plants of Cincinnati, Ohio, and Vicinity, by W. H. Aiken.

No. 16. BOTANY SERIES No. 2, BY ALFRED J. MORRISON, PH. D.
Reise durch einige der mittlern und sudlichen vereinigten Nordamerikanischen Staaten nach Ost-Florida und den Bahama Inseln unternommen in den Jahren 1783 und 1784, von Johann David Schöpf, Erlangen, by Johann Jacob Palm, 1788.

No. 17. PHARMACY SERIES No. 3, BY PROFESSOR L. E. SAYER.
Gelsemium. A study that embodies the recent work of Prof. L. E. Sayre, Lawrence, Kansas, together with fragments of a paper read by him before the American Pharmaceutical Association, Richmond, Virginia, 1910, accompanied by a plate of physiological tracings by Prof. H. W. Emerson.

No. 18. PHARMACY SERIES No. 4, BY JOHN URI LLOYD.
History of the Vegetable Drugs of the Pharmacopeia of the United States, by John Uri Lloyd, Phar. M., with portraits of Charles Rice, Ph. D., New York, N. Y., elected Chairman of the Pharmacopeial Committee on Revision, who died May 13, 1901 (see portrait), and Joseph P. Remington, Ph. M., Philadelphia, Pa. (see portrait), Dr. Rice's successor as Chairman of the Revision Committee, under whom the work appeared.

No. 19. PHARMACY SERIES No. 5, BY HENRY WICKERS FELTER.
Introduction by John Uri Lloyd. Biographies of John King, M. D., Andrew Jackson Howe, A. B., M. D., and John Milton Scudder, M. D. Accompanied by Many Valuable and Historical Portraits and Other Illustrations.

No. 20. MYCOLOGICAL SERIES No. 6.
Syopsis of the Stipitate Polyporoids, by C. G. Lloyd.

No. 21. ENTOMOLOGICAL SERIES No. 1.
The Biology of North American Caddis Fly Larvae, by John Thomas Lloyd.

No. 22. ENTOMOLOGICAL SERIES No. 2.
Notes on the Biology of some of our North American Species of Mayflies, by Helen E. Murphy.

No. 23. ENTOMOLOGICAL SERIES No. 3.
Morphology, Anatomy and Ethology of Nemoura, by Chenfu Francis Wu.

No. 24. ENTOMOLOGICAL SERIES No. 4.
Neotropical Mayflies, by James G. Needham and Helen E. Murphy.